THE ADDYSTON PIPE & STEEL CO.

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CAST-IRON PIPE.

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THE ADDYSTON PIPE AND STEEL COMPANY.

[Tables for flow of water through pipes]

WORKS:

ADDYSTON, OHIO. —•—●—•— NEWPORT, KY.

OFFICES:

COR. THIRD & WALNUT, CINCINNATI, O.

CINCINNATI:
C. J. Krehbiel and Company.
248-250 WALNUT ST.
1892.

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THE ADDYSTON PIPE AND STEEL CO.

CINCINNATI, OHIO, 1892.

The Company, in offering this book, does not wish to convey the idea that it contains everything relative to either gas or water pipe. It is presented with the hope that the information contained may, as far as it goes, be serviceable to those using castings of this character or others of our manufacture.

We desire to render credit to the following named hydraulic and civil engineers for many of the tables and much of the information herein contained: Jno. W. Rutherfoord, Jno. W. Hill, J. D. Cook; also to G. A. Ellis and A. H. Howland for tables of "Flow of Water in Pipes."

Also to the following engineering works which we consulted during the compilation of the work: Humber, Fanning, Haswell, Trautwine, Molesworth, and Box.

We trust that this publication may meet the wants of those for whose benefit it is compiled.

THE ADDYSTON
PIPE AND STEEL COMPANY.

ANNOUNCEMENT.

THE ADDYSTON PIPE AND STEEL COMPANY, organized under the laws of the State of Ohio, and having a paid-up capital of $1,500,000, owns and operates the works formerly known as the Cincinnati and Newport Iron and Pipe Company, of which it is the successor.

In conjunction with the works purchased, The Addyston Pipe and Steel Company has erected an entirely new plant at Addyston, Ohio, fitted with every new and improved appliance adapted to the best manufacture of Cast Iron Pipe and other castings, and with the increase of capacity and facilities the Company is enabled to offer special inducements to all buyers, in the direction of speedy delivery, as well as low prices.

Particular attention is given to the manufacture of the following castings:

WATER-PIPE.

PIPE FOR NATURAL OR MANUFACTURED GAS.

SEWER AND CULVERT PIPE.

SPECIALS OR BRANCH CASTINGS.

FLANGE PIPE FOR WATER, GAS, AND STEAM.

ELEVATOR CYLINDERS AND PLUNGERS.

BLAST-FURNACE CASTINGS.

CAST IRON STILLS AND KETTLES.

SEWER CASTINGS.

LAMP-POSTS.

LARGE CASTINGS OF EVERY DESCRIPTION.

ROLLING-MILL CASTINGS.

HEAVY MACHINERY A SPECIALTY.

HISTORY OF WATER MAINS IN AMERICA.

PROBABLY the first pipes used for water mains in this country were bored logs, joined together by driving the sharpened end of one log into a corresponding hollow in the end of the next log. In certain soils these pipes answered fairly well for a limited time for conducting water under a low pressure, but the material of which they were made rotted so readily in most soils that, in spite of their low first cost, the water-works builders demanded pipes of some more suitable material.

In 1804 the first cast pipes were laid in Philadelphia, and, although cast on their sides, thus rendering them in many cases twice as thick on one side as the other, their use rapidly increased. To remedy the many defects caused by this imperfect mode of casting, the pipe manufacturers entirely altered their processes, and with new machinery and new methods cast their pipe on end, thus insuring an even thickness of metal and a solid casting.

After these unprotected cast pipes had been in use for a long time, certain kinds of water were found to form tubercular accretions and rust inside of them, thus impeding the flow of water. About twenty-five years ago cast pipe for water mains began to be protected from these accretions by the coating now in general use, and in this manner such formations were entirely prevented.

The many advantages obtained by the use of cast-iron coated pipe have recently been verified by letters from many of the water-works of this country that testify to its numerous advantages. In view of this, it is amusing to see how the magnificent results of this coated cast pipe are totally ignored in the recent publications of the manufacturers of wrought pipe coated with cement or other material, and how the record of the un-

protected mains, in which tubercular accretions *sometimes* collected, is used against the present coated pipes, which are the only cast pipes sold for water mains.

In 1845 *wrought pipe*, coated inside and out with cement and sand, was laid for water mains, and its use was largely increased during the war in consequence of the extremely high price of iron, which rendered the wrought pipe, on account of its comparative lightness, much cheaper, *apparently*, than cast pipe. We say *apparently*, for in almost every city where this pipe has been in use for any length of time it has been replaced by cast pipe, as is the case in so many cities of Massachusetts and other states where it had been put in. This wrought pipe has only remained serviceable in a very few instances, where unusually favorable circumstances caused its preservation.

Lightning has a particular affinity for this wrought pipe, and many mains have been ruined in this manner. In a publication issued in the interest of cement-lined pipe it is stated that the cast pipe in Halifax, N. S., was struck by lightning. This is incorrect, as Mr. Keating, Superintendent of the Halifax Water Works, advises us that the accident referred to was caused *solely* by a washout. We are unaware of any cast pipe having been destroyed by lightning.

Recently a wrought pipe, coated inside and out with pure cement, *without* an admixture of sand, has been placed upon the market. It is difficult to understand how this pipe can be expected to give any better results than that last mentioned, as pure cement cracks more readily than a mixture of cement and sand. This pipe also differs from the former, having an outer wrought shell to enable the manufacturer to make it at his factory instead of at the point of laying. An additional element of danger is thus introduced, as the jarring during transportation is very liable to crack the cement, and its inspection and repair is entirely prevented by this outside wrought shell.

Galvanized Iron Pipe was also tried. This pipe is made by coating ordinary wrought pipe with zinc. Its short life, high cost, and the danger of poisonous salts of zinc being formed in the water passing through this kind of pipe, soon caused its abandonment.

We here append a clipping from the *Engineering News* of October 3, 1885, bearing on the subject:

"Galvanized-iron Water Pipes.—In the course of a paper on the above subject by Dr. F. P. Venable, in the *Journal* of the American Chemical Society, he states that it has long been known that zinc dissolves in water, and that soft water, such as rain water, dissolves it more easily than hard water. Water containing carbonic acid is specially able to dissolve it. The use of galvanized iron for pipes and tanks being so much on the increase, the subject becomes more and more important, and it is desirable to ascertain, as far as possible, to what extent solution of the zinc coating takes place, and how far water contaminated by zinc is injurious to health. The author quotes several investigators as to the latter point, the evidence being to some extent conflicting, but giving a very decided balance on the side of the view that such water is considerably injurious. Investigations made on behalf of the French Government resulted in the prohibition by the Ministry of Marine of the use of galvanized-iron tanks on board men-of-war. Professor Heaton has given an analysis of a spring water, with a further analysis of the same water after it had traveled through half a mile of galvanized-iron pipe. It had taken up 6.41 grains of zinc carbonate per gallon. Dr. Venable gives the results of an observation of his own, where spring water passed through 200 yards of galvanized-iron pipes to a house, and took up 4.29 grains of zinc carbonate per gallon. It therefore seems pretty clear that drinking-water should not be allowed to come in contact with zinc."

The excellent results obtained by the coating used on cast pipe suggested the idea that *wrought pipe* coated in the same manner might be correspondingly protected. In practice, however, it was found that the polished surface formed on the wrought pipe by passing the plates from which they were made through the rolls prevented this or other coatings from clinging tightly to the pipe, and soon caused the abandonment of pipe so coated for use as water mains. In the face of these results, however, attempts are now being made to sell, for underground conduits, *spirally welded wrought pipe* of extremely thin metal, the life of which depends on the protection afforded by a coating similar to this.

Kalamein Pipe.—Owing to the high price of tin its use as a preventive of rusting in wrought-iron water pipe has not been feasible, and many attempts have been made to form a cheaper coating by alloying tin with lead or other cheaper metals. On November 16, 1880, an alloy

for *coating* iron was patented, the proportions of its ingredients being about as follows:

Lead	53.93 per cent.
Zinc	32.00 " "
Tin	14.00 " "
Nickel	.07 " "
	100.00

By this process, which is called *calameining*, the inventor "is enabled to use *a large quantity of lead* in combination with zinc, tin and nickel," to form an alloy for coating. On June 10th and October 7, 1884, patents were also issued in which the percentage of *lead was still further increased* to from 60 to 80 per cent., slight changes made in the other ingredients of the alloy, and a fraction of one per cent. of copper added. Wrought pipe coated with this alloy is called "*Kalamein Pipe.*" The large percentage of lead in this pipe has caused great objection to its use, owing to the fear that water passing through it might become contaminated, thus causing lead poisoning. The danger from this cause is not fancied, for in Massachusetts alone there are many well-authenticated cases in numerous towns and cities of persons becoming lead-poisoned by drinking water which had passed through lead pipes. (See Massachusetts Board Health Report, 1871.)

This pipe is also extremely thin; a ten-inch pipe, for example, is but slightly over one-eighth of an inch thick, while the ordinary standard wrought pipe is about one-third of an inch, and cast-iron water pipe nine-sixteenths of an inch in thickness. Owing to its extreme thinness the life of Kalamein pipe must indeed be short, if its coating is not indestructible. The tests made by Professor Charles O. Thompson, of the Rose Polytechnic Institute, for The American Water-Works Association, and the trouble which several cities have already experienced in its use, throw grave doubt on the protection afforded by this coating. We understand that, in spite of the alleged indestructibility of this Kalamein coating, a still further protection is now given this pipe by coating it with tar and asphalt, but for reasons already pointed out it is not probable that this coating can add much to the life of this pipe.

Wyckoff Pipe.—Wooden logs, bound with thin iron bands and coated on the outside with tar and sawdust, were also tried as mains. This pipe, called Wyckoff Wooden Pipe, was laid by Grand Rapids and Grand Haven (Michigan), Wichita (Kansas), Middletown (New York), New Lisbon (Ohio), and many other cities, and the expense which they have undergone in replacing it with cast pipe does not speak very favorably of its merits. In some soils it may last many years, but trouble is usually experienced a few years after it is laid, on account of the rusting of the imperfectly protected wrought bands and the rotting of the wood; this is particularly the case in the more recently made pipes, as it is becoming more and more difficult to obtain logs that are suitable for this purpose, owing to the rapid destruction of our forests.

The claim made for all these pipes is their small cost, in comparison with those of cast iron. Their *first* cost is somewhat less; but with all due deference to the manufacturers of these different compositions, this is the most that can be said in their favor.

We can not recall a single instance where any city has discarded the use of cast-iron pipe for any of these inferior substitutes; but instances can be multiplied where pipes of other material have been taken up to be replaced by those of cast iron. Nothing but cast iron is now used in all our large cities, the field of those dealing in patent rights for inferior pipe being the smaller towns and villages; and here the citizens or trustees find to their cost that the investment has been a very expensive one, notwithstanding the claims made to them as to the small cost. New York, Brooklyn, Cincinnati, Louisville, Philadelphia, Toledo, Pittsburgh, Cleveland, Buffalo, New Orleans, Memphis, Atlanta, Columbus, Milwaukee, St. Louis, and all the cities where engineers are employed in their water departments, use nothing but cast-iron water pipe. The late Hon. A. W. Craven, formerly Chief Engineer of the Croton Aqueduct Department, New York, says:

"*In cast iron you are dealing with a certainty. . . . . I do not consider it true economy to use any known substitute in any portion of the distribution of a town.*"

NATURAL GAS PIPES.

The use of cast-iron pipes as conduits for natural gas has increased to such proportions that we give below some of the advantages obtained by their use.

Durability.—The life of cast pipe is unknown, as even the imperfect pipes first made in this country in 1804 are now in good condition, in spite of the fact that they are uncoated, and were cast on their sides, thus causing one side to be two or three times as thick as the other.

Pipes have only been coated during the last twenty-five or thirty years, and those first protected in this manner are now found as perfect as when laid.

The smoothness caused by rolling iron or steel prevents this coating from clinging tightly to wrought-iron or steel pipes, and for this reason it can not be depended upon to preserve *these* pipes from rusting, and from becoming, after a time, worthless as conduits for natural gas.

The short life of these pipes when laid in the ground is also well shown by the numerous attempts which have been made to lengthen their life by coating them with zinc, kalamein, cement, asphalt, or other materials. (See pages 8, 9 and 10.)

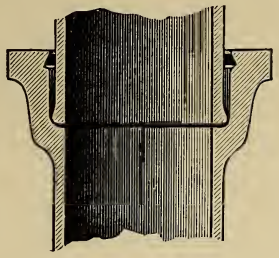
The material of which cast pipes are manufactured and their thickness, which is several times greater than that of wrought pipe, clearly proves the reliability and durability of cast-iron pipe.

If the supply of natural gas fails, the cast pipe lines can be taken up and used elsewhere, or, if broken up, a large return can be realized from the scrap.

Cast pipe is not porous, as is proven by the fact that the natural gas lines of Pittsburgh and other cities show no lowering of the pressure of the compressed air contained in them, although allowed to stand closed up for hours while being tested.

Cast pipe is found equally tight in body and joint under natural gas pressure, as was exemplified in the test of The Equitable Natural Gas Line at Pittsburgh, where the line, although constructed of light-weight pipe, withstood successfully a natural gas pressure of one hundred and fifty pounds. The same result was also attained in the test of The Versailles Fuel Gas Company's lines at McKeesport, Pa., where their twelve and

fourteen-inch cast pipe successfully withstood a natural gas pressure of two hundred pounds, although pipes of ordinary water weights were used.



Joint.—The advantage of the joint used on our cast pipe is well shown by the fact that two of the largest manufacturers of wrought pipes are making their pipes with joints made as nearly as possible like that used on cast pipes, although the advantage gained by the raised bead on the cast pipes can not be obtained in either of the wrought-pipe joints, as in one the bead is replaced by two small rivets and in the other by a groove cut into the spigot end of the pipe. The body of these lead-jointed wrought pipes is much thinner than even standard wrought screw pipe, and their life, when laid in the ground, is correspondingly shorter.

It has been proven by experience that the joint on cast pipe remains absolutely tight under a pressure of five thousand pounds per square inch, and that a plug will withstand a pressure of four thousand pounds per square inch before being forced from the socket into which it is leaded.

Cast iron expands one-eleventh less than wrought iron, and as cast iron will stretch twice as much as wrought iron within elastic limits, there is no strain on the cast-pipe joint. (For data see "Trautwine's Pocket Manual," page 212.)

As cast iron expands or contracts only one-eighth of an inch in 1,688 feet for one degree of heat, if the pipe line varies fifteen degrees in temperature there will be a variation of one-eighth of an inch in one hundred and thirteen feet, making a variation of only one-seventy-second of an inch in the length of each cast pipe, which is twelve feet long. Wrought iron varies one-eighth of an inch in only 1,562 feet for each one degree raise or lowering of temperature. If the pipe changes fifteen degrees in tempera ture, it will expand or contract one-eighth of an inch in only one hundred and four feet.

If wrought pipes are twenty-six feet long, there will then be an expansion of one-thirty-second of an inch in each joint; if eighteen feet long, one-forty-sixth of an inch in each joint; while, as above shown, there is an expansion of only one-seventy-second of an inch in each joint of cast pipe. This will be allowed for fully by the packing in the cast-iron joint, while there is nothing in the screw joint to take up this contraction, particularly as Trautwine shows (page 212) that wrought iron will only stretch one-half as much as cast iron within elastic limits.

When natural gas was first discovered two lines of cast pipes were laid in Pennsylvania, whose failure to successfully carry five hundred pounds pressure is often alluded to by our wrought pipe competitors, as these are the only cast iron gas lines, as far as we are aware, which have not given perfect satisfaction. When it is understood that these pipes were the thinnest manufactured, and were intended only to carry gas under a few ounces of pressure; that they were purchased from many manufacturers through a broker, and therefore had differently shaped joints; that they were laid through an extremely rocky and rough country by men who had never laid cast pipes before, the surprise is, not that the lines did not carry gas under a pressure of five hundred pounds successfully, but that they were used to carry gas under *pressures as high as two hundred pounds* per square inch for several years.

Cost.—For pipe of medium size it is safe to say that cast pipe *laid in the ground* is as cheap as wrought pipe *on cars*. As the size of the pipe increases, this difference in cost in favor of cast pipe over lap-weld wrought pipe increases with surprising rapidity.

The great advantage obtained by using large pipe is hardly, we think, appreciated, for one twenty-four-inch pipe, twenty miles long, will deliver as much gas as twenty 8-inch pipes of the same length.

The loss of pressure on account of friction is extremely high in small lines, and it is usual to figure on a diminution in pressure of from six to eight pounds per mile in an eight-inch pipe; in the thirty-inch, and also in the twenty-four-inch cast pipe lines of The Equitable Natural Gas Company, of Pittsburgh, a loss but slightly over a pound per mile is experienced.

CAPACITY AND FACILITIES.

Our works, being as large and as thoroughly fitted up as any in the country, have a complete assortment of the most improved machinery for making pipe and other castings. A brief description of our mode of manufacture is here appended.

METHOD OF MELTING.

Our cupolas are of the most improved pattern. In advance of the general custom, all iron, fuel, and flux, composing the mixture, is accurately weighed and analyzed. Thus, when any inferiority arises in the quality of casting we are enabled at once to trace and remedy the evil, thereby avoiding damage to our customers by the shipment of weak or defective pipe.

From each day's cast, bars are made by which the tensile strain is determined, thus regulating the uniformity of our work.

MACHINE SHOPS.

Included in and made a part of our works are extensive and thoroughly equipped departments for all machine work. The same being replete with modern tools and machinery, enables us to reach every branch of work attendant upon the pipe business. We have special and complete facilities for facing, drilling, and finishing for immediate use, flange pipe and flange castings of all descriptions.

We can, of course, face and drill our hydraulic cylinders or cylinders for smoke stacks when desired.

FLASKS AND PATTERNS.

Having been so long engaged in the manufacture of iron castings we have a stock of flasks and patterns sufficient to cover every demand for pipe, cylinders, and other castings.

OVENS.

By the use of our superior drying ovens the drying of the mold proceeds from the surface coming in contact with the molten metal, preventing honey-combing in the casting, as no moisture arises from the perfectly dried surface. By the use of gas, with which all our cores and molds at Addyston are heated, a thoroughly uniform drying is attained.

COATING.

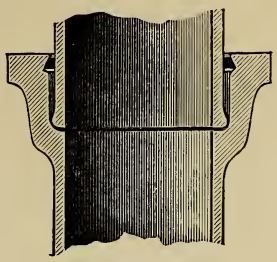
When preferred, we coat our pipes with Dr. Angus Smith's patent preservative varnish. This process of coating cast pipe has now been in use for over twenty-five years, and therefore ample time has elapsed for the thorough testing of its efficiency. In order to obtain accurate information on this very important subject we wrote to the heads of the water departments of many principal cities, and learned that this coating absolutely prevents the formation of tubercular accretions, or rust, in the pipe.

In many tables showing the discharge from cast pipes the advantage obtained by the use of coated pipe has not been calculated upon. Mr. J. F. Bateman, F. R. S., states that "the four-feet pipes at Glasgow were calculated to deliver twenty million gallons in twenty-four hours with five feet per mile inclination. They (being coated) have delivered twenty-six million with three and one-half feet."

TESTING.

All pipe over two inches in diameter is subjected to a hydrostatic pressure of 300 pounds per square inch; an additional test is made while the pipe is under this pressure, by striking it throughout its length with an iron hammer, thus making apparent any flaw or imperfection existing.

SOCKET AND SPIGOT.

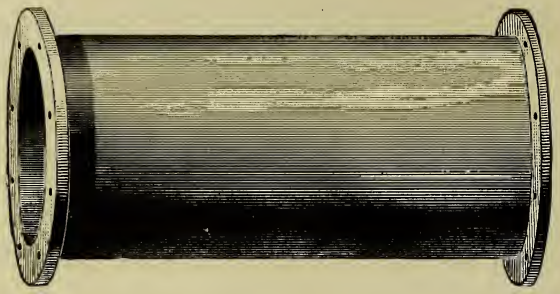


We would call special attention to the socket and spigot ends of our pipe. When joints are properly made it is impossible for them to separate, or for leakage to occur when under pressure. These necessary results are attained by introducing into the interior of the socket a wedge-shaped recess called the lead ring, which being filled with lead obviates all possibility of a withdrawal of the bead end from the socket, and when under pressure tends to tighten the joint. Since the bead rests firmly against the sockets on all sides, it will be seen that it is impossible for the lead when poured to enter into the pipe through imperfect packing.

By our improved method of casting the beads or spigot ends they are uniform and unchilled, thus strengthening the part of the pipe most exposed in handling.

Further, our pipes are cast with our patent bell-shaped socket, thus causing the entering or spigot end of the pipe to be centered by the tapered sides of the socket.

CYLINDERS.



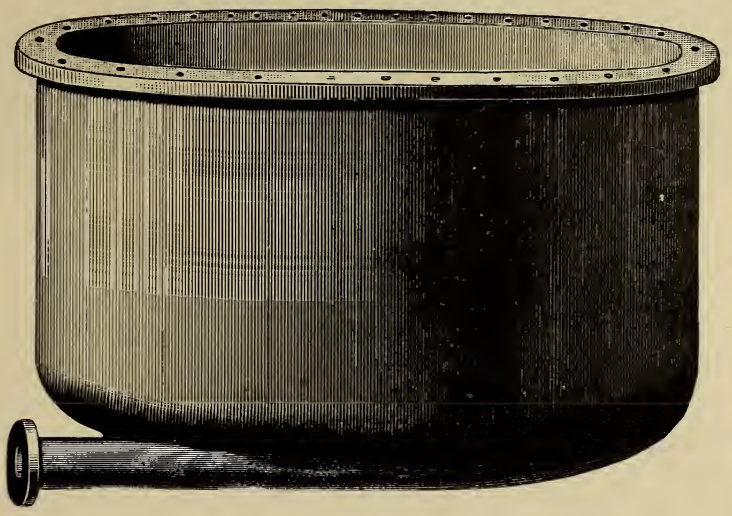
In this connection we desire to say we depart from the usual custom and cast all hydraulic Cylinders, Rolls for paper-mill machinery, Smoke Stacks, and other Tubular Castings, on end with iron core bars, thus giving uniform thickness and additional strength.

By means of careful and extensive analyses and exhaustive tests by our chemist, we have arrived at most satisfactory mixtures of iron for the manufacture of castings requiring unusual strength and tenacity.

FLANGE PIPE.

To supply the ever-increasing demand for this class of pipe, we have put in a pit especially designed to make them rapidly and cheaply, and are therefore particularly well fitted to supply the needs of our customers who may desire them. These can be promptly faced and drilled in our machine shops if required.

STILLS AND KETTLES.



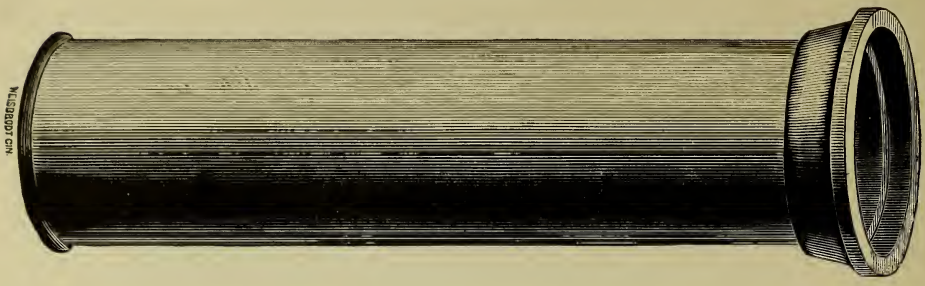
We have patterns for the casting of stills and kettles of various capacities, and are prepared to make in loam those differing from the patterns which we have.

GENERAL FOUNDRY WORK.

Our new molding floor, which is supplied with the most approved cranes, over-head travelers and flasks, enables us to furnish promptly, and at a very low price, castings of all kinds. We make a specialty, however, of very large castings, such as the stills above referred to, blast furnace castings, large specials, and loam castings of every description.

Our new machine shops, equipped with tools of most modern design, enable us to face, drill or otherwise machine castings, if our customers so desire.

CULVERT PIPE.



We have complete arrangements for the manufacture or cast-iron pipe of large diameters, for railroad or turnpike culverts. These pipes are usually cast to lay twelve feet, but shorter lengths can be furnished when desired. We also reserve such pipes which, through some slight defect, do not fulfill the severe requirements which we demand of our pipes, but which are thoroughly suitable and reliable for culvert pipe. Whenever we have any of these pipes on hand we supply them to our customers at an extremely low figure.

The railroads of this country thoroughly appreciate the many advantages derived from the use of cast-iron culvert pipe, and a considerable percentage of the larger sizes of pipes made by us are furnished for this purpose. Among the exceptional advantages to be derived from the use of this class of culverts we desire to call attention to the following:

1. *Ease and cheapness* in laying; no concrete foundation is required, as in the case of properly laid vitrified pipe, and joints (which can be of cement) occur only once in twelve feet

2. *Durability*. The enormous strength of this pipe prevents crushing, and the coating with which all our pipe is covered entirely prevents rusting.

3. *Discharge*. A larger discharge can be obtained through this than through any other kind of culvert, owing to its smooth surface, few joints, and perfect alignment.

4. *Reliability*. As one piece of our pipe lays twelve feet it may be used instead of six 2-foot vitrified pipes, thus eliminating the danger from undermining by water, the leaking from five joints, and also removing the danger of unequal settlement, as our pipe has a bearing six times as great as that of the two-foot vitrified pipe.

BRIDGE PIERS AND SUBMARINE FOUNDATIONS.

We are also prepared to make sections of cast-iron cylinders for bridge piers and submarine foundations. These sections are made in diameters and lengths as may be required, and from one to two inches in thickness of shell. The flanges are internal, drilled for bolts, and of any required size. The castings are squared in a lathe so as to present the best appearance and make a perfect joint. These cylinders coated with our patent preparation of coal tar are claimed to be superior to wrought-iron caissons.

We recently sank a caisson of this description on our own property in order to place our artesian well pumps as close to the water supply as possible. It was composed of eight cylinders ten feet in diameter and six feet high. In place of a bottom flange the lower rim of the caisson was tapered to facilitate its sinking into the earth.

Many large railroads have adopted castings of this description for bridge piers.

We devote especial attention to these branches of our business and we respectfully invite correspondence, or will visit personally parties who may desire anything of the above description.

TABLE SHOWING WEIGHTS OF EMBANKMENT MATERIALS PER CUBIC FOOT.

MATERIAL.	AV. WEIGHT.	SPECIFIC GRAVITY.	AV. VOIDS.
Granite	166 pounds.	2.666	. . . . .
Coarse Gravel	120 "	1.925	.28 per cent.
Gravel	116 "	1.861	.30 "
Sharp Sand	110 "	1.765	.33 "
Clay	125 "	1.440	.12 "
Water	62.5 "	1.000	. . . . .

To determine the pressure per square foot of embankment upon the horizontal surface of the pipe, multiply the weights above given by height of fill above the pipe.

STOCK ON HAND.

For the convenience of our regular customers and of parties requiring pipe in emergencies, we keep on hand a considerable stock of both gas and water pipe, special branch castings and large sizes of pipe for culverts. The variety of standards makes it almost impossible to meet entirely the wishes of every one ordering from our stock. From long experience, however, we believe we have adopted safe standards; these we endeavor to have constantly on hand to supply our customers' wants. Should they, however, wish weights of their own, we shall use our best endeavors to meet their views.

We here append table showing weights and thicknesses of pipe as manufactured by us.

WEIGHTS OF STANDARD GAS PIPE.

Internal Diameter in Inches.	Thickness of Shell in Inches.	Weight per Foot in Pounds.	Weight per Pipe in Pounds.	Laid Length.
2	$\frac{5}{16}$—	6	48	8
3	$\frac{5}{16}$+	12½	150	12
4	$\frac{3}{8}$	17	204	12
5	$\frac{7}{16}$	24	288	12
6	$\frac{7}{16}$+	30	360	12
8	$\frac{7}{16}$+	40	480	12
10	$\frac{7}{16}$+	50	600	12
12	$\frac{1}{2}$	70	840	12
14	$\frac{9}{16}$	84	1,000	12
16	$\frac{9}{16}$—	100	1,200	12
18	$\frac{11}{16}$—	134	1,600	12
20	$\frac{11}{16}$—	150	1,800	12
24	$\frac{3}{4}$ —	184	2,200	12

For other weights see page 24.

WEIGHTS OF STANDARD WATER PIPE.

Internal diameter in Inches.	Approx. thickness of Shell in Inches.	Weight per Foot in Pounds.	Weight per Length in Pounds.	Laid Length.
2	$\frac{5}{16}$	7	63	9
3	$\frac{3}{8}$	15	180	12
3	$\frac{1}{2}$	17	204	12
4	$\frac{1}{2}$	22	264	12
5	$\frac{1}{2}$	27	324	12
6	$\frac{1}{2}$	33	396	12
8	$\frac{1}{2}$—	42	504	12
8	$\frac{1}{2}$	45	540	12
10	$\frac{9}{16}$	60	720	12
12	$\frac{9}{16}$	75	900	12
12	$\frac{5}{8}$	80	960	12
14	$\frac{3}{4}$	117	1,400	12
16	$\frac{3}{4}$—	125	1,500	12
18	$\frac{7}{8}$	167	2,000	12
20	$1\frac{5}{16}$	200	2,400	12
24	1—	250	3,000	12
30	$1\frac{1}{8}$	350	4 200	12
36	$1\frac{3}{8}$	475	5,700	12
48	$1\frac{1}{2}$	775	9,300	12
60	2	1,330	15.960	12

For other weights see page 24.

The above weights are the usual ones required, but of course may be varied to accommodate our customers.

TABLES SHOWING WEIGHTS OF CAST IRON PIPE, WITH ALLOWANCE ADDED FOR BOWL AND SPIGOT ENDS, AS MANUFACTURED BY US.

Weights in Columns, per Foot Lineal. Iron, .2604 per Cubic Inch.

Inter'l Diam. in Inches.	Thickness of Iron Shell in Inches.													
	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 3/4	2.
	Equivalents in Decimals of an Inch.													
	.125	.250	.375	.500	.625	.750	.875	1	1.125	1.250	1.375	1.500	1.625	2.
2	3	6	9.3	14	19									
3	4	9	13	18	23	29								
4	5	11	17	23.5	30	37	44	52						
5	6.5	13.5	21	29	36	45	53	62						
6	8	16.5	25	34	43	53	63	73						
8	10	21.5	32.5	44	56	68	81	93						
10	14	27	40.5	55	69	84	99	114						
12	15	32	48	65	82	100	117	135	153	172				
14	18	37	56	75	95	115	137	159	177	198				
16	20	41	64	86	108	130	153	176	201	224				
18	22	47	72	96	121	146	172	197	224	250	276			
20	26	52.5	79	107	134	162	190	216	247	275	305	336	398	458
24	32	63	95	127	160	192	225	259	293	330	364	398	470	543
30	40	78	118	158	198	238	278	318	358	405	449	493	577	664
35	45	90	135	180	225	270	315	360	405	450	495	540	668	766
36	47	94	141	188	235	282	335	384	433	483	533	583	686	788
40	52	104	156	208	260	312	364	413	465	517	569	621	762	875
42	55	110	165	221	276	331	386	442	496	552	608	662	718	912
48	63	125	189	252	315	379	444	510	573	640	705	771	904	1039
50	65	130	197	262	328	395	463	531	597	667	734	803	942	1082
52	68	135	203	270	338	406	473	537	605	672	740	807	991	1138
56	73	146	218	291	364	437	510	578	651	723	797	869	1067	1225
58	75	151	229	304	380	458	537	616	693	774	851	931	1093	1255
60	80	156	239	316	396	476	556	636	716	810	898	986	1154	1328

Above weights are only approximate, as actual weights will vary with the dimensions of the sockets used.

THICKNESS OF CAST-IRON PIPE REQUIRED FOR VARIOUS PRESSURES WHEN TENSILE STRAIN IS 18,000 LBS. PER SQUARE INCH.

DIAMETER.	Class A, Pressure 50 lbs. per Square Inch or less. Head 116 Feet.			Class B, Pressure 100 lbs. per Square Inch. Head 230 Feet.			Class C, Pressure 130 lbs. per Square Inch. Head 300 Feet.		
	THICKNESS.		Approx. weight per foot in lbs.	THICKNESS.		Approx. weight per foot in lbs.	THICKNESS.		Approx. weight per foot in lbs.
Inches.	Inches.	Apprx. in.		Inches.	Apprx. in.		Inches.	Apprx. in.	
3	.3858	$\frac{3}{8}$	14.5	.4066	$\frac{13}{32}$	15	.4191	$\frac{7}{16}$	17
4	.4033	$\frac{13}{32}$	18.5	.4311	$\frac{7}{16}$	21	.4477	$\frac{7}{16}$	22
6	.4383	$\frac{7}{16}$	30	.4800	$\frac{1}{2}$	33	.5050	$\frac{1}{2}$	34
8	.4734	$\frac{1}{2}$	42	.5289	$\frac{17}{32}$	47	.5622	$\frac{9}{16}$	50
10	.5083	$\frac{1}{2}$	55	.5777	$\frac{19}{32}$	63	.6194	$\frac{5}{8}$	67
12	.5433	$\frac{9}{16}$	71	.6266	$\frac{5}{8}$	82	.6766	$\frac{11}{16}$	88
14	.5783	$\frac{19}{32}$	87	.6755	$\frac{11}{16}$	102	.7338	$\frac{3}{4}$	111
16	.6166	$\frac{5}{8}$	108	.7277	$\frac{3}{4}$	127	.7944	$\frac{13}{16}$	137
18	.6483	$\frac{21}{32}$	127	.7733	$\frac{25}{32}$	152	.8483	$\frac{27}{32}$	166
20	.6833	$\frac{11}{16}$	150	.8222	$\frac{27}{32}$	180	.9055	$\frac{29}{32}$	200
24	.7533	$\frac{3}{4}$	196	.9200	$\frac{15}{16}$	240	1.0200	1	265
30	.8583	$\frac{7}{8}$	275	1.0666	$1\frac{1}{16}$	345	1.1916	$1\frac{3}{16}$	384
36	.9633	$\frac{31}{32}$	370	1.2133	$1\frac{7}{32}$	470	1.3633	$1\frac{3}{8}$	527
48	1.1733	$1\frac{3}{16}$	607	1.5066	$1\frac{1}{2}$	777	1.7066	$1\frac{11}{16}$	880
60	1.4110	$1\frac{7}{16}$	910	2.0000	2	1,328	2.2500	$2\frac{1}{4}$	1 500

The thicknesses in the above table are based upon FANNING'S formula.

$$t=\frac{(p+100)d}{.4\,S}+.333\left\{1-\frac{d}{100}\right\}$$

where t=thickness in inches, p=pressure in pounds, d=diameter of pipe in inches, and S=tensile strain in pounds per square inch.

The above table is calculated with a safety factor of ~~ten~~ 5, *i. e.*, the tensile strain would be ~~1,800~~ 3,600 lbs. if no allowance was made for co-efficient of safety. An additional allowance of 100 lbs. to the pressure exerted is added in the above table for water ram.

THICKNESSES OF CAST IRON PIPE USED IN SEVERAL CITIES.

Diameter Inches.	Philadelphia.	New York.	Baltimore	Brooklyn.	St. Louis.	Chicago.	Cleveland.	Providence.	Lowell.	Rochester.	Fall River.	Allegheny.	Detroit.	Albany.	Milwaukee.	Cincinnati.	Diameter Inches.
	Head Pressure for which Pipe are classed, in feet.																
	115 250 . .	100	218 . . 	120 170 198	130 170 . .	125	150	100 140 180	130 170 200	150 200 . .	80 140 260	162	100 . .	144 200	150 200	. . . . . .	
	Thickness of Pipe Shells, in Inches.																
4	3/8	. .	7/16	. .	1/2	5/8	1/2	. .	. .	1/2	3/8	1/2	7/16	1/2	. .	1/2	4
6	7/16	1/2	7/16	9/16	17/32	. .	1/2+	1/2	7/16	5/8	15/32	1/2	7/16	1/2	15/32	1/2	6
6	. .	. .	. .	21/32	9/16	5/8−	. .	1/2	1/2	7/8	5/8	. .	. .	5/8	1/2	1/2	6
8	7/16+	. .	1/2	1/2	9/16	. .	1/2	1/2	1/2	7/8	17/32	5/8	1/2	1/2	1/2	. .	8
8	.	. .		21/32	5/8+	5/8	. .	9/16	9/16	.	3/4	.	. .	5/8	9/16	9/16	8
10	1/2	. .	1/2	. .	5/8−	. .	5/8	19/32	. .	3/4	19/32	. .	1/2	5/8	. .	5/8−	10
12	9/16	5/8	11/16	5/8	21/32	3/4	3/4	9/16	19/32	3/4	5/8	3/4	9/16	5/8	9/16	5/8	12
12	. .	. .	. .	13/16	23/32	.	. .	21/32	5/8+	1	15/16	. .	. .	3/4	5/8	. .	12
16	5/8	3/4	13/16	. .	. .	3/4+	3/4+	21/32	11/16	3/4	3/4	3/4	5/8	3/4	11/16	. .	16
16	.	. .	. .	. .	. .	. .	. .	3/4	3/4	1	1 1/8	. .	. .	7/8	. .	7/8	16
20	11/16	3/4	15/16	7/8	13/16	. .	7/8	23/32	. .	3/4	7/8	1	3/4	. .	3/4	7/8	20
20	. .	. .	. .	1	15/16+	. .	. .	29/32	.	1	1 5/16	. .		. .	7/8	. .	20
24	.	7/8	. .	. .	. .	1	7/8+	13/16	13/16	3/4	3/4	1	. .		15/16	. .	24
24	. .	. .	. .	. .	. .	. .	.	15/16	15/16+	1	1		. .	.	1	. .	24
30	15/16	1	1 1/8	1 3/32	1 1/32	. .	1 1/8	39/32	15/16+	7/8	. .	1 1/8	. .	. .	1	1 1/16	30
30	. .	. .	. .	1 3/8	1 1/4	. .	. .	1	1 1/8	. .	. .	.	. .	. .	1 1/16	. .	30
30	. .	. .	.	. .	. .	. .	. .	1 1/16	1 5/16	1 1/8	. .	. .	. .	. .	. .	. .	30
36	1 1/8	1	. .	1 1/8	1 1/8+	.	1 3/16	1	. .	. .	. .	1 1/8	1	. .	. .	. .	36
36	. .	. .	. .	. .	1 5/8	. .	. .	1 1/4	. .	. .	. .	. .	. .	. .	. .	1 1/8	36
48		1 1/4	. .	1 5/16	1 3/8	. .	. .	.	. .	. .	. .	. .	. .	. .	. .	1 1/2	48

Weight per Running Foot of Pipes or Cylinders with no Allowance for Hub, Spigot, or Flange.

Inner Diam. or Bore in Inches.	THICKNESS OF PIPE IN INCHES.												
	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1¾	2
	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.	Wt. in Lbs.
2.	5.53	8.76	12.3	16.2	20.3	24.8	29.5	34.6	40.0	45.7	51.7	64.6	78.7
3.	7.98	12.5	17.2	22.3	27.7	33.4	39.4	45.7	52.3	59.2	66.4	81.8	98.4
4.	10.3	16.1	22.2	28.5	35.1	42.0	49.2	56.7	64.6	72.7	81.2	99.0	118.
¼	11.1	17.1	23.4	30.0	36 9	44.1	51.7	59.5	67.7	76.1	84.9	103.	123.
½	11.7	18.0	24.6	31.5	38.8	46.3	54.1	62.3	70.7	79.5	88.6	108.	128.
¾	12.3	18.9	25.8	33.1	40.6	48.5	56.6	65.0	73.8	83.9	92.3	112.	133.
5.	12.9	19.8	27.1	34 6	42.5	50.6	59.1	67.8	76.9	87.2	96.0	116.	138.
¼	13.5	20.8	28.3	36.1	44.3	52.8	61.5	70.6	80.0	90.6	99.6	121.	143.
½	14.2	21.7	29.5	37.7	46.1	54.9	64.0	73.3	83.0	94.0	103.	125.	148.
¾	14.8	22.6	30.8	39.2	48.0	57.1	66.4	76.1	86.1	97.4	107.	129.	153.
6.	15.4	23.5	32.0	40.8	49.8	59.2	68.9	78.9	89.2	99.8	111.	134.	158.
½	16.6	25.4	34.5	43.8	53.5	63.5	73.8	84.4	95.3	107.	118.	142.	167.
7.	17.8	27.2	36.9	46.9	57.2	67.8	78.7	89.4	102.	113.	126.	151.	177.
½	19.1	29.1	39.4	50.0	60.9	72.1	83.7	95.5	108.	120.	133.	159.	187.
8.	20.3	30.9	41.8	53.1	64.6	76.4	88.6	101.	114.	127.	140.	168.	197.
½	21.5	32.8	44.5	56.1	68.3	80.7	93.5	107.	120.	134.	148.	177.	207.
9.	22.8	34.6	46.8	59.2	72.0	85.1	98.4	112.	126.	140.	155.	185.	217.
½	24.0	36.4	49.2	62.3	75.7	89.3	103.	118.	132.	147.	163.	194.	226.
10.	25.1	38.3	51.7	65.3	79.4	93.6	108.	123.	138.	154.	170.	202.	235.
½	26.4	40.1	54.1	68.4	83.0	97.9	113.2	129.	145.	161.	177.	211.	245.
11.	27.6	42.0	56.6	71.5	86.7	102.	118.	134.	151.	168.	185.	220.	255.
½	28.8	43.8	59.1	74.6	90.4	107.	123.	140.	157.	174.	192.	228.	265.
12	30.0	45.7	61.5	77.7	94.1	111.	128.	145.	163.	181.	199.	237.	275.
13	32.5	49.4	66.4	83.8	102.	120.	138.	156.	175.	195.	214.	254.	294.
14	35.0	53.1	71.4	89.4	109.	128.	148.	168.	188.	208.	229.	271.	314.
15	37.4	56.7	76.3	96.1	116.	137.	158.	179.	200.	222.	244.	289.	334.
16	39.1	60.4	81.2	102.	124.	145.	167.	190.	212.	235.	258.	306.	353.
17	42.3	64.1	86.1	108.	131.	154.	177.	201.	225.	249.	273.	323.	373.
18	44.8	67.8	91.0	115.	139.	163.	187.	212.	237.	262.	288.	340.	393.
19	47.3	71.5	96.0	121.	146.	171.	197.	223.	249.	276.	303.	357.	412.
20	49.7	75.2	101.	127.	153.	180.	207.	234.	261.	289.	317.	375.	432.
21	52.2	78.9	106.	133.	161.	188.	217.	245.	274.	303.	332.	392.	452.
22	54.6	82.6	111.	139.	168.	196.	227.	256.	286.	316.	347.	409.	471.
23	57.1	86.3	116.	145.	175.	206.	236.	267.	298.	330.	362.	426.	491.
24	59.6	89.9	121.	152.	183.	214.	246.	278.	311.	343.	375.	444.	511.
25	62.0	93.6	126.	158.	190.	223.	256.	289.	323.	357.	391.	461.	531.
26	64.5	97.3	131.	164.	198.	231.	266.	300.	335.	370.	406.	478.	550.
27	66.9	101.	135.	170.	205.	240.	276.	311.	348.	384.	421.	495.	570.
28	69.4	105.	140.	176.	212.	249.	286.	323.	360.	397.	436.	512.	590.
29	71.8	109.	145.	182.	220.	257.	295.	334.	372.	411.	450.	530.	609.
30	74.2	112.	150.	188.	227.	266.	305.	345.	384.	424.	465.	547.	629.
31	76.7	116.	155.	195.	234.	275.	315.	356.	397.	438.	480.	564.	649.
32	79.1	120.	160.	201.	242.	283.	325.	367.	409.	451.	495.	581.	668.
33	81.6	123.	165.	207.	249.	292.	335.	378.	421.	465.	509.	598.	688.
34	84.1	127.	170.	213.	257.	300.	345.	389.	434.	479.	524.	616.	708.
35	86.5	131.	175.	219.	264.	309.	354.	400.	446.	492.	539.	633.	726.
36	89.0	134.	180.	225.	271.	318.	364.	411.	458.	506.	554.	650.	746.
42	104.	156.	210.	262.	315.	370.	423.	478.	532.	588.	644.	753.	864.
48	119.	178.	239.	298.	359.	422.	482.	544.	605.	669.	733.	856.	982.

STANDARD FLANGE PIPE FOR WATER AND STEAM.

TO CARRY A PRESSURE OF 100 LBS. PER SQUARE INCH.

(*All dimensions in Inches.*)

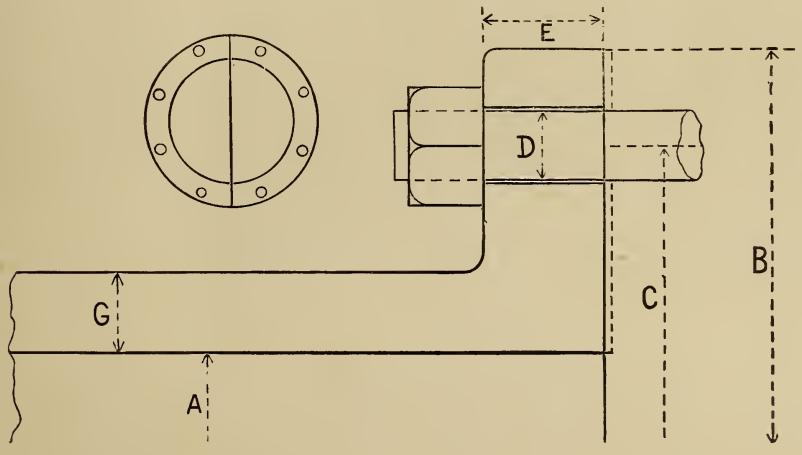
Inside diameter of Pipe. A	Outside diameter of Flange. B	Diameter of Bolt Circle on Centers. C	Diameter of Rough Bolt. D	Thickness of Finished Flange. E	No. of Bolts. I	Thickness of Pipe. G	Weight per Foot.
3	8	6¼	⅝	¾	4	0.47	17
4	9	7¼	⅝	¾	4	0.47	22
6	11	9¼	⅝	⅞	6	0.48	33
8	13	11½	¾	⅞	8	0.54	48
10	16	14	¾	1	10	0.60	65
12	18	16¼	¾	1	12	0.66	85
14	21	18⅝	⅞	1⅛	14	0.72	110
16	23	21	⅞	1⅛	16	0.78	135
18	25	23	⅞	1⅛	18	0.84	165
20	27	24⅝	⅞	1¼	18	0.90	200
24	31	29⅜	1	1¼	20	1.02	265
30	38	35⅝	1⅛	1⅜	24	1.20	384
36	45	42⅛	1¼	1½	30	1.39	540
42	52	48½	1½	1¾	36	1.57	677
48	58½	54½	1½	2	42	1.75	904

STANDARD FLANGE PIPE FOR GAS.

TO CARRY A PRESSURE OF 1 LB. PER SQUARE INCH.

(*All dimensions in Inches.*)

Inside diameter of Pipe. A	Outside diameter of Flange. B	Diameter of Bolt Circles on Centers. C	Diameter of Rough Bolts. D	Finished Thickness of Flanges. E	Approx. Thickness of Pipe. G	Weight per Foot of Pipe in Lbs.	Number of Bolts
6	11	$9\frac{1}{4}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{7}{16}$	30	4
8	13	$11\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{7}{16}$	40	4
10	16	14	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{7}{16}$	50	8
12	18	16	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	70	8
14	20	$17\frac{3}{4}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{9}{16}$	84	8
16	22	$19\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{9}{16}$	100	8
18	24	$21\frac{3}{4}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{11}{16}$	134	8
20	26	$23\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{11}{16}$	150	8
24	31	$27\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	185	12
30	$37\frac{1}{2}$	$33\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	275	12



WATER.

Without designing to give an elaborate treatise on hydraulics and hydrostatics, we shall endeavor to present to those interested a few tables and formulas pertaining to these inexhaustible topics, which we think will be found of use, together with a few facts not heretofore brought to notice in a work of this description.

In cities, towns, or villages contemplating building water-works, the first and most important point to decide is the source of supply. It should be accessible, the quality pure, and the quantity bountiful. Chemically pure water consists of two gases, oxygen and hydrogen, in the proportion of 88.9 of the former to 11.1 of the latter, or 2 measures hydrogen to 1 of oxygen. However, *chemically pure* water is neither obtainable nor desirable for ordinary public and domestic uses. In that state it is unsuited to the various needs of communities and individuals. All investigation teaches that the purest waters are generally found in running streams. Notwithstanding their occasional turbidity from suspended sediments, they promote more readily the precipitation of impurities, and present a greater surface for the oxydizing influence of the atmosphere. Rain-water, at the time of its transition from vapor to water, may be considered pure, but before reaching the earth, especially in populous manufacturing districts, it absorbs and carries with it poisonous gases and other atmospheric impurities, and we accordingly have pure air after "refreshing showers," while cistern waters become proportionately impure, and emit unpleasant odors when kept confined in closely covered cisterns. The great solvent properties of water render it an attractive receptacle for extraneous solids and gases. While percolating the earth, it absorbs mineral and other soluble substances. From the surface it absorbs both animal and vegetable impurities. Surface impurities are found both in suspension and solution. Suspended impurities usually impart turbidity or color to the water, and are removed by subsidence or filtration, while those in solution can be removed only by distillation.

Mr. J. D. Cook, the eminent hydraulic engineer of Toledo, to whose report we are indebted, and who has given the subject much study and attention, says: "Organic impurities may be regarded as two-fold in origin and effect. As found in rivers with ordinarily clean shores, they ger

erally result from vegetable decomposition, and are rarely harmful in quality or quantity. Mineral impurities are frequently beneficial. Well waters usually hold considerable quantities of lime and magnesia in solution, producing what is termed 'hard water.' Moderately hard waters, if otherwise pure, are not seriously objectionable for drinking, but for ordinary domestic purposes are unsuited. One very serious objection, however, to the use of well water, especially in thickly settled districts, is the liability of wells to act as natural and convenient depositories for the worst phases of pollution, the drainage from kitchens, stables, out-houses, etc.—pollutions the sources of which never cease, but constantly increase. The water may be clear and cold, and yet contain impurities of the most dangerous nature. Waters which are impregnated, even to a fearful extent with organic pollution, are frequently limpid, inodorous, and pleasant to the taste. Cities contemplating using water from any source, should employ an expert chemist to make satisfactory tests. When we reflect that water constitutes three-fourths of the human organism; that ninety-five per cent. of the blood and about eighty per cent. of our food is water, or its elements, its purity and healthfulness become matters of the most vital imporance."

A TABLE SHOWING WEIGHT OF WATER PER CUBIC FOOT, AT DIFFERENT TEMPERATURES.

TEMPERATURE, ° FAHRENHEIT.	POUNDS PER CUBIC FOOT.	TEMPERATURE, ° FAHRENHEIT.	POUNDS PER CUBIC FOOT.
32°	62.37	62°	62.31
40°	62.38	70°	62.25
50°	62.36	80°	62.20
60°	62.33	86°	62.13

The maximum density of water is when its temperature is 39.2°. From this point it expands by either cold or heat; when the temperature of 32° reduces it to solid ice, its weight is only 57.2 pounds per cubic foot, expanding by freezing $\frac{1}{12}$ of its original bulk as water, and the sudden

expansive force exerted at the moment of freezing has been calculated to be equal to 30,000 pounds per square inch.

A cubic foot of salt water weighs 64.3 pounds. The ice from sea water is fresh; freezes at 27° Fahr.

RAINFALL.

The grand source of supply is from the clouds. They are the reservoirs on which we depend for replenishing our streams, springs, wells, and other terrestrial sources. In many places the storage of the rainfall in reservoirs and tanks is the only resource the inhabitants have to get a supply of water for any purpose. In India immense ponds or "tanks," as they are called, are built at government expense, and being filled during the rainy season, are the only places where water can be obtained to support life during the torrid season. During the rainy season immense quantities of rain fall in that country. In Madras the fall is 47 inches per annum; in Calcutta, 60 inches—maximum in 16 years, 82 inches; in Delhi, 21 inches; on the Khassya hills, north of Calcutta, 500 inches, or 41 feet 8 inches, have fallen in the 6 rainy months. In other mountainous districts of India annual falls of 10 to 20 feet are common. In the United States the rainfall varies in different localities, although there are few places where an annual fall of at least 24 inches may not safely be expected. In making calculations for storage reservoirs, either to supply cities, or feed canals, we can not safely assume more than the minimum fall observed during a term of years, or rather somewhat less. Under ordinary circumstances of locality, about one-half of this may be collected. From this must be deducted the amount lost by evaporation and leakage. The amount lost by the former process on water exposed to the effects of the open air is of course greatest during warm weather, greater in shallow than in deep water, and greater in running than in still water. *Trautwine* estimates that in the United States, the evaporation from a reservoir of ordinary depth rarely exceeds .3 of an inch per diem during June, July, and August, or .1 of an inch during the other months of the year. These two averages would give a daily average of .15 inch, or a total annual loss of 55 inches, or 4 feet 7 inches. The same distinguished engineer, from trials made by himself in the tropics, in ponds of pure water 8 feet deep, in a stiff retentive clay,

and fully exposed to a very hot sun (the thermometer ranging from 115° to 125°), discovered that the loss during the dry season was precisely 2 inches in 16 days—⅛ inch per day—while the evaporation from a glass tumbler was ¼ inch per day.

In reservoirs the loss from filtration through the banks and the earth is combined with the loss by evaporation. If the quantity is very small, it is dried up at once by the sun and air as fast as it reaches the outside, but if in greater quantity it becomes apparent and shows itself as leakage.

The total average loss from all causes in reservoirs of moderate depth and proper construction will not exceed .75 to 1 inch per day, but in new ones it will usually be greater.

To illustrate the weight of water by the amount per inch of rain on one acre: An inch of rain amounts to 3,630 cubic feet, or 27,155 U. S. gallons, or 100 tons per acre; or 2,323,200 cubic feet or 17,379,200 U. S. gallons, or 64,000 tons per square mile.

SUBMERGED PIPE.

In crossing streams, and in laying inlet pipes, it is sometimes found advisable to place flexible joints at various points in the line in order to allow for inequalities in the bottom over which the pipe is laid.

It is customary to join four pieces of ordinary bell-and-spigot pipe together by the usual lead joint, and, after lowering them to the bottom, to connect them to the pipe already laid by means of a ball-and-socket joint; a diver then tightens the bolts, joining the two parts of the joint. This method has been used in many river crossings, and has always given perfect satisfaction when properly laid.

QUANTITY OF WATER REQUIRED IN CITIES.

The quantity of water required in cities has been found to increase much faster than the population. From 30 to 40 gallons per capita per day in non-manufacturing towns, and from 60 to 70 per day in large commercial cities, ought to be sufficient; but experience shows that many cities consume largely over the above figures. With economy to prevent wastage, about 60 gallons per day would be a fair allowance; but inasmuch as our cleanliness, comfort, and health are dependent on its free use, as few restrictions as possible should be placed on it.

FLOW OF WATER IN CLEAN CAST-IRON BITUMINIZED WATER PIPES, UNDER THE AVERAGE CONDITIONS OF PRACTICAL WORK.

The following tables are intended to be sufficiently accurate for ordinary use. The curve of resistance adopted is greater than that of *M. Darcy*, and less than that of *Eytelwein*. The figures are given to the nearest decimal, and are probably nearer than the conditions under which they might be used would ever twice agree.

Their application is threefold. First: To ascertain the frictional resistance or loss of head or pressure within any size pipe, while discharging given quantities of water. Second: Conversely, to find out the quantity of water flowing in any size pipe, from the reduction of pressure. Third: To ascertain the maximum volume which any size water pipe will discharge under a given head.

The frictional resistance is found when the quantity is known by multiplying the figures under that heading by the distance in 1,000 feet, using the columns of "Feet" or "Pounds" as circumstances may require. In most cases, that of pounds will be more practical.

Suppose, for instance, a fire occurs. Four fire streams are used, aggregating 700 gallons per minute; water supplied through 9,500 feet of 16-inch, and 1,500 feet of 6-inch pipe. In the tables we find the frictional loss against 700 gallons per minute in the 16-inch pipe to be .171 pounds, which for 9,500 feet would be 1.62 pounds, and in the 6-inch pipe, 19.083 pounds; or, for 1,500 feet, 28.62 pounds. Combining both pipes we have a loss in excess of 30 pounds. These figures are on the basis of no other draught of water from the pipes. If, however, the ordinary flow was 1,000 gallons a minute in the 16-inch, and 200 gallons a minute in the 6-inch, then the loss should be calculated from the figures in the tables for 1,700 and 900 gallons a minute in the respective sizes, and the actual loss of pressure for fire protection would amount to about 56 pounds.

The volume of *water flowing* is found by ascertaining the loss of pressure for each thousand feet of pipe, and opposite to the nearest corresponding number in the column of frictional head in the proper table will

be found the volume. For instance, in a 6-inch pipe, two gauges a thousand feet apart show a difference or loss of pressure of 1 pound; the nearest figures show the flow to be 150 gallons a minute. If the loss was 10 pounds, we should in the same way find a flow of 500 gallons a minute. With a 16-inch pipe, 12,000 feet long, and an observed loss of pressure of 3 pounds, the loss per 1,000 feet would be 0.25 pounds, and the number of gallons per minute rather more than 850.

It is necessary to observe, that to make such use of the tables the gauges used must *exactly* agree with each other at all points, or if only one is used that it be absolutely correct, and the static pressure at the level of the gauge accurately known. When two gauges are used their difference of level must be allowed for.

The maximum quantity which any size pipe will discharge is found by dividing the total head at the point of discharge, either pounds or feet, by the length (if the entire pipe is below the hydraulic grade line), and finding thus the hydraulic grade per 1,000 feet, run down the column of frictional head to the nearest figure, and opposite we have the volume.

This is not strictly correct, as the total head is composed of the frictional, velocity, and entrance heads, and the latter two should be subtracted before dividing.

The velocity head is given in the first column of the tables, and the entrance head is practically one-half as much as the velocity head (unless the entrance is bell-mouthed, when no allowance is necessary). An inspection of the table shows at once whether any correction is necessary for sufficient accuracy. To illustrate: head 215, but distance 2 miles; wanted two million gallons in 24 hours; this gives fall per 1,000 feet 20.359 feet, or nearest below in an 8-inch pipe, 950 gallons per minute, or 1,368,000 in 24 hours; same in a 10-inch pipe, 1,675 gallons per minute, or 2,412,000 in 24 hours. In neither of these cases would the velocity and entrance heads together amount to one foot, or an average reduction of not over 0.1 foot per 1,000, which would not change the figures found.

For high velocity or close work it will not do to omit the correction.

4-Inch Pipe—1,000 Feet Long.

Head in feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
	.64	25	.589	.255	36,000	1.62	10.21	400	109.675	47.502	576,000
.03	1.28	50	2.010	.871	72,000	1.83	10.85	425	123.635	53.555	612,000
.06	1.91	75	4.267	1.848	108,000	2.05	11.49	450	138.431	59.957	648,000
.10	2.55	100	7.359	3.188	144,000	2.29	12.13	475	154.063	66.727	684,000
.16	3.19	125	11.288	4.889	180,000	2.53	12.77	500	170.530	73.870	720,000
.23	3.83	150	16.053	6.954	216,000	2.79	13.40	525	187.834	81.361	756,000
.31	4.47	175	21.654	9.379	252,000	3.06	14.04	550	205.973	89.221	792,000
.41	5.11	200	28.090	12.168	288,000	3.35	14.68	575	224.948	97.441	828,000
.51	5.74	225	35.363	16.720	324,000	3.65	15.32	600	244.760	106.019	864,000
.63	6.37	250	43.471	18.831	360,000	3.96	15.96	625	265.407	114.963	900,000
.77	7.02	275	52.415	22.704	396,000	4.28	16.60	650	286.890	124.276	936,000
.91	7.66	300	62.196	26.941	432,000	4.62	17.23	675	309.209	133.939	972,000
1.07	8.29	325	72.812	31.540	468,000	4.96	17.87	700	332.364	143.979	1,008,000
1.24	8.94	350	84.264	36.504	504,000	5.33	18.51	725	356.355	154.363	1,044,000
1.42	9.57	375	96.552	41.827	540,000	5.70	19.15	750	381.181	165.121	1,080,000

6-Inch Pipe—1,000 Feet Long.

	.28	25	.107	.046	36,000	1.20	8.79	775	54.431	23.577	1,116,000
	.57	50	.322	.139	72,000	1.28	9.08	800	57.948	25.101	1,152,000
.01	.85	75	.646	.260	108,000	1.36	9.36	825	61.575	26.672	1,188,000
.02	1.13	100	1.081	.468	144,000	1.45	9.65	850	65.312	28.291	1,224,000
.03	1.42	125	1.626	.702	180,000	1.53	9.93	875	69.160	29.960	1,260,000
.05	1.70	150	2.281	.988	216,000	1.62	10.21	900	73.117	31.671	1,296,000
.06	1.99	175	3.046	1.319	252,000	1.71	10.49	925	77.184	33.430	1,332,000
.08	2.27	200	3.921	1.698	288,000	1.81	10.78	950	81.362	35.237	1,368,000
.10	2.55	225	4.906	2.125	324,000	1.90	11.06	975	85.650	37.102	1,404,000
.13	2.84	250	6.002	2.600	360,000	2.00	11.35	1,000	90.047	38.988	1,440,000
.15	3.12	275	7.207	3.122	396,000	2.10	11.63	1,025	94.555	40.958	1,476,000
.18	3.40	300	8.522	3.692	432,000	2.21	11.92	1,050	99.173	42.960	1,512,000
.21	3.68	325	9.948	4.309	468,000	2.31	12.20	1,075	103.901	45.000	1,548,000
.24	3.97	350	11.484	4.975	504,000	2.42	12.48	1,100	108.739	47.104	1,584,000
.28	4.25	375	13.129	5.690	540,000	2.53	12.76	1,125	113.687	49.247	1,620,000
.32	4.54	400	14.885	6.446	576,000	2.65	13.05	1,150	118.745	51.438	1,656,000
.36	4.82	425	16.751	7.268	612,000	2.76	13.33	1,175	123.913	53.677	1,692,000
.41	5.11	450	18.727	8.111	648,000	2.88	13.61	1,200	129.192	55.963	1,728,000
.45	5.39	475	20.813	9.015	684,000	3.00	13.89	1,225	134.580	58.291	1,764,000
.50	5.67	500	23.009	9.967	720,000	3.13	14.18	1,250	140.078	60.674	1,800,000
.55	5.95	525	25.315	10.966	756,000	3.25	14.46	1,275	145.687	63.108	1,836 000
.60	6.24	550	27.731	12.011	792,000	3.38	14.75	1,300	151.406	65.576	1,872,000
.66	6.52	575	30.258	13.107	828,000	3.51	15.03	1,325	157.234	68.101	1,908,000
.72	6.81	600	32.894	14.249	864,000	3.65	15.32	1,350	163.173	70.685	1,944,000
.78	7.09	625	35.640	15.439	900,000	3.78	15.60	1,375	169.222	73.296	1,980,000
.85	7.38	650	38.497	16.678	936,000	3.92	15.88	1,400	175.381	75.965	2,016,000
.91	7.66	675	41.464	17.960	972,000	4.06	16.16	1,425	181.650	78.682	2,052,000
.98	7.94	700	44.540	19.083	1,008,000	4.21	16.45	1,450	188.029	81.443	2,088,000
1.05	8.22	725	47.727	20.674	1,044,000	4.35	16.73	1,475	194.518	84.254	2,124,000
1.13	8.51	750	51.024	22.101	1,080,000	4.50	17.02	1,500	201.118	87.121	2,160,000

6-Inch Pipe—Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD. Feet.	FRICTION HEAD. Pounds.	U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD. Feet.	FRICTION HEAD. Pounds.	U. S. Gallons discharged per twenty-four Hours.
4.65	17.30	1,525	207.827	90.018	2,196,000	6.31	20.14	1,775	280.975	121.712	2,556,000
4.81	17.59	1,550	214.646	92.969	2,232,000	6.48	20.42	1,800	288.895	125.138	2,592,000
4.96	17.87	1,575	221.576	95.981	2,268,000	6.67	20.71	1,825	296.926	128.621	2,628,000
5.12	18.15	1,600	228.616	99.027	2,304,000	6.85	20.99	1,850	305.066	132.144	2,664,000
5.29	18.44	1,625	235.765	102.041	2,340,000	7.03	21.27	1,875	313.316	135.761	2,700,000
5.45	18.72	1,650	243.025	105.271	2,376,000	7.22	21.56	1,900	321.677	139.343	2,736,000
5.62	19.01	1,675	250.395	108.462	2,412,000	7.42	21.84	1,925	330.148	143.014	2,772,000
5.78	19.29	1,700	257.875	111.699	2,448,000	7.61	22.13	1,950	338.728	146.731	2,808,000
5.95	19.57	1,720	265.465	114.991	2,484,000	7.81	22.41	1,975	347.419	150.494	2,844,000
6.13	19.86	1,750	273.165	118.331	2,520,000	8.00	22.69	2,000	356.220	154.304	2,880,000

8-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.16	25	.036	.016	36,000	.51	5.74	900	17.681	7.694	1,296,000
	.32	50	.096	.042	72,000	.54	5.90	925	18.656	8.081	1,332,000
	.48	75	.182	.078	108,000	.57	6.06	950	19.656	8.514	1,368,000
	.64	100	.294	.127	144,000	.60	6.22	975	20.683	8.959	1,404,000
.01	.80	125	.433	.188	180,000	.63	6.38	1,000	21.735	9.414	1,440,000
.01	.96	150	.597	.259	216,000	.66	6.54	1,025	22.814	9.882	1,476,000
.02	1.12	175	.788	.341	252,000	.70	6.70	1,050	23.919	10.361	1,512,000
.03	1.28	200	1.005	.435	288,000	.73	6.85	1,075	25.050	10.851	1,548,000
.03	1.44	225	1.248	.541	324,000	.76	7.01	1,100	26.208	11.352	1,584,000
.04	1.60	250	1.517	.657	360,000	.80	7.17	1,125	27.391	11.865	1,620,000
.05	1.76	275	1.812	.785	396,000	.83	7.33	1,150	28.600	12.389	1,656,000
.06	1.91	300	2.133	.923	432,000	.87	7.50	1,175	29.836	12.924	1,692,000
.07	2.07	325	2.481	1.074	468,000	.91	7.66	1,200	31 098	13.470	1,728,000
.08	2.23	350	2.854	1.236	504,000	.95	7.82	1,225	32.386	14.029	1,764,000
.09	2.39	375	3.254	1.410	540,000	.99	7.98	1,250	33.699	14.598	1,800,000
.10	2.55	400	3.680	1.594	576,000	1.03	8.14	1,275	35.040	15.178	1,836,000
.11	2.71	425	4.132	1.790	612,000	1.07	8.30	1,300	36.406	15.770	1,872,000
.13	2.87	450	4.610	1.997	648,000	1.11	8.46	1,325	37.798	16.373	1,908,000
.14	3.03	475	5.114	2.215	684,000	1.16	8.62	1,350	39.217	16.988	1,944,000
.16	3.19	500	5.644	2.445	720,000	1.20	8.78	1,375	40.661	17.613	1,980,000
.17	3.35	525	6.201	2.686	756,000	1.24	8.94	1,400	42.132	18.251	2,016,000
.19	3.51	550	6.783	2.938	792,000	1.29	9.10	1,425	43.629	18.899	2,052,000
.21	3.67	575	7.392	3.202	828,000	1.33	9.25	1,450	45.152	19.559	2,088,000
.23	3.83	600	8.026	3.477	864,000	1.38	9.41	1,475	46.701	20.230	2,124,000
.25	3.99	625	8.687	3.763	900,000	1.42	9.57	1,500	48.276	20.912	2,160,000
.27	4.15	650	9.374	4.061	936,000	1.47	9.73	1,525	49.877	21.605	2,196,000
.29	4.31	675	10.088	4.370	972,000	1.52	9.89	1,550	51.505	22.310	2,232,000
.31	4.47	700	10.827	4.690	1,008,000	1.57	10.05	1,575	53.158	23.026	2,268,000
.33	4.62	725	11.592	5.021	1,044,000	1.62	10.21	1,600	54.838	23.754	2,304,000
.35	4.78	750	12.384	5.364	1,080,000	1.67	10.37	1,625	56.544	24.493	2,340,000
.38	4.93	775	13.201	5.718	1,116,000	1.72	10.53	1,650	58.275	25.243	2,376,000
.40	5.09	800	14.045	6.083	1,152,000	1.78	10.69	1,675	60.033	26.002	2,412,000
.43	5.25	825	14.915	6.460	1,188,000	1.83	10.85	1,700	61.818	26.782	2,448,000
.46	5.43	850	15.811	6.849	1,224,000	1.88	11.00	1,725	63.628	27.562	2,484,000
.48	5.59	875	16.733	7.246	1,260,000	1.94	11.16	1,750	65.464	28.357	2,520,000

8-inch Pipe—Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
1.99	11.31	1,775	67.327	29.164	2,556,000	3.06	14.04	2,200	102.987	44.612	3,168,000
2.05	11.47	1,800	69.215	29.982	2,592,000	3.13	14.20	2,225	105.319	45.622	3,204,000
2.11	11.64	1,825	71.130	30.811	2,628,000	3.21	14.36	2,250	107.678	46.644	3,240,000
2.17	11.80	1,850	73.071	31.652	2,664,000	3.28	14.52	2,275	110.063	47.677	3,276,000
2.23	11.97	1,875	75.038	32.504	2,700,000	3.35	14.68	2,300	112.474	48.721	3,312,000
2.29	12.13	1,900	77.031	33.368	2,736,000	3.42	14.84	2,325	114.911	49.775	3,348,000
2.35	12.29	1,925	79.051	34.243	2,772,000	3.50	15.00	2,350	117.375	50.842	3,384,000
2.41	12.45	1,950	81.096	35.125	2,808,000	3.57	15.16	2,375	119.864	51.914	3,420,000
2.47	12.61	1,975	83.167	36.026	2,844,000	3.65	15.32	2,400	122.380	53.005	3,456,000
2.53	12.77	2,000	85.265	36.935	2,880,000	3.73	15.48	2,425	124.922	54.109	3,492,000
2.60	12.93	2,025	87.389	37.855	2,916,000	3.80	15.64	2,450	127.489	55.222	3,528,000
2.66	13.08	2,050	89.539	38.786	2,952,000	3.88	15.80	2,475	130.083	56.346	3,564,000
2.73	13.24	2,075	91.715	39.729	2,988,000	3.96	15.96	2,500	132.703	57.485	3,600,000
2.79	13.40	2,100	93.917	40.683	3,024,000	4.04	16.12	2,525	135.350	58.632	3,636,000
2.86	13.56	2,125	96.145	41.648	3,060,000	4.12	16.28	2,550	138.022	59.780	3,672,000
2.93	13.72	2,150	98.399	42.624	3,096,000	4.20	16.44	2,575	140.720	60.952	3,708,000
3.00	13.88	2,175	100.680	43.613	3,132,000	4.28	16.60	2,600	143.445	62.133	3,744,000

10-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.10	25	.016	.007	36,000	.13	2.86	700	3.656	1.584	1,008,000
	.20	50	.040	.017	72,000	.14	2.96	725	3.911	1.694	1,044,000
	.31	75	.072	.031	108,000	.15	3.06	750	4.174	1.808	1,080,000
	.41	100	.113	.049	144,000	.16	3.16	775	4.446	1.926	1,116,000
	.51	125	.162	.070	180,000	.17	3.27	800	4.726	2.047	1,152,000
	.61	150	.220	.095	216,000	.18	3.37	825	5.015	2.172	1,188,000
	.71	175	.286	.124	252,000	.19	3.47	850	5.313	2.301	1,224,000
.01	.82	200	.361	.156	288,000	.20	3.57	875	5.619	2.434	1,260,000
.01	.92	225	.444	.192	324,000	.21	3.68	900	5.933	2.570	1,296,000
.02	1.02	250	.536	.232	360,000	.22	3.78	925	6.256	2.710	1,332,000
.02	1.12	275	.637	.276	396,000	.24	3.88	950	6.588	2.854	1,368,000
.02	1.23	300	.746	.323	432,000	.25	3.98	975	6.928	3.001	1,404,000
.03	1.33	325	.864	.374	468,000	.26	4.08	1,000	7.277	3.152	1,440,000
.03	1.43	350	.990	.429	504,000	.27	4.18	1,025	7.635	3.307	1,476,000
.04	1.53	375	1.125	.487	540,000	.28	4.28	1,050	8.000	3.46[illegible]	1,512,000
.04	1.63	400	1.268	.549	576,000	.30	4.38	1,075	8.375	[illegible]	1,548,000
.05	1.73	425	1.420	.615	612,000	.31	4.49	1,100	8.758	3.794	1,584,000
.05	1.83	450	1.581	.685	648,000	.33	4.59	1,125	9.150	3.964	1,620,000
.06	1.93	475	1.750	.758	684,000	.34	4.69	1,150	9.550	4.137	1,656,000
.06	2.04	500	1.927	.835	720,000	.36	4.79	1,175	9.958	4.314	1,692,000
.07	2.14	525	2.114	.916	756,000	.37	4.90	1,200	10.376	4.495	1,728,000
.08	2.24	550	2.308	1.000	792,000	.39	5.00	1,225	10.802	4.679	1,764,000
.08	2.34	575	2.512	1.084	828,000	.40	5.10	1,250	11.236	4.867	1,800,000
.09	2.45	600	2.723	1.179	864,000	.42	5.20	1,275	11.679	5.058	1,836,000
.10	2.55	625	2.944	1.275	900,000	.44	5.31	1,300	12.131	5.254	1,872,000
.11	2.65	650	3.173	1.374	936,000	.46	5.41	1,325	12.591	5.454	1,908,000
.12	2.75	675	3.410	1.477	972,000	.47	5.51	1,350	13.059	5.657	1,944,000

10-Inch Pipe—Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.49	5.61	1,375	13.536	5.864	1,980,000	1.25	8.98	2,200	34.086	14.765	3,168,000
.51	5.72	1,400	14.022	6.074	2,016,000	1.28	9.09	2,225	34.855	15.098	3,204,000
.53	5.82	1,425	14.517	6.288	2,052,000	1.31	9.19	2,250	35.631	15.434	3,240,000
.54	5.92	1,450	15.019	6.505	2,088,000	1.34	9.29	2,275	36.417	15.775	3,276,000
.56	6.02	1,475	15.531	6.727	2,124,000	1.37	9.39	2,300	37.211	16.118	3,312,000
.58	6.13	1,500	16.051	6.953	2,160,000	1.40	9.49	2,325	38.013	16.467	3,348,000
.60	6.23	1,525	16.579	7.181	2,196,000	1.43	9.59	2,350	38.824	16.808	3,384,000
.62	6.33	1,550	17.117	7.414	2,232,000	1.46	9.69	2,375	39.644	17.173	3,420,000
.64	6.43	1,575	17.662	7.650	2,268,000	1.49	9.80	2,400	40.472	17.531	3,456,000
.66	6.53	1,600	18.216	7.891	2,304,000	1.52	9.90	2,425	41.309	17.894	3,492,000
.68	6.63	1,625	18.779	8.134	2,340,000	1.56	10.00	2,450	42.154	18.260	3,528,000
.70	6.73	1,650	19.351	8.382	2,376,000	1.59	10.11	2,475	43.008	18.630	3,564,000
.72	6.83	1,675	19.931	8.633	2,412,000	1.62	10.21	2,500	43.870	19.003	3,600,000
.75	6.94	1,700	20.519	8.888	2,448,000	1.65	10.31	2,525	44.741	19.381	3,636,000
.77	7.04	1,725	21.116	9.146	2,484,000	1.68	10.41	2,550	45.621	19.762	3,672,000
.79	7.14	1,750	21.722	9.409	2,520,000	1.72	10.52	2,575	46.509	20.146	3,708,000
.81	7.24	1,775	22.336	9.676	2,556,000	1.75	10.62	2,600	47.405	20.535	3,744,000
.84	7.35	1,800	22.959	9.946	2,592,000	1.79	10.72	2,625	48.311	20.927	3,780,000
.86	7.45	1,825	23.590	10.218	2,628,000	1.82	10.82	2,650	49.224	21.323	3,816,000
.88	7.55	1,850	24.230	10.496	2,664,000	1.85	10.92	2,675	50.147	21.722	3,852,000
.91	7.65	1,875	24.878	10.777	2,700,000	1.89	11.03	2,700	51.078	22.125	3,888,000
.93	7.76	1,900	25.535	11.061	2,736,000	1.93	11.13	2,725	52.017	22.532	3,924,000
.96	7.86	1,925	26.201	11.349	2,772,000	1.96	11.23	2,750	52.965	22.942	3,960,000
.98	7.96	1,950	26.875	11.641	2,808,000	2.00	11.33	2,775	53.922	23.357	3,996,000
1.01	8.06	1,975	27.557	11.937	2,844,000	2.03	11.43	2,800	54.887	23.775	4,032,000
1.04	8.17	2,000	28.249	12.236	2,880,000	2.07	11.53	2,825	55.860	24.196	4,068,000
1.06	8.27	2,025	28.948	12.539	2,916,000	2.10	11.63	2,850	56.843	24.622	4,104,000
1.09	8.37	2,050	29.657	12.847	2,952,000	2.14	11.73	2,875	57.833	25.051	4,140,000
1.12	8.47	2,075	30.374	13.157	2,988,000	2.18	11.84	2,900	58.833	25.484	4,176,000
1.14	8.58	2,100	31.099	13.471	3,024,000	2.22	11.94	2,925	59.841	25.921	4,212,000
1.17	8.68	2,125	31.833	13.789	3,060,000	2.25	12.04	2,950	60.857	26.361	4,248,000
1.20	8.78	2,150	32.576	14.112	3,096,000	2.29	12.14	2,975	61.882	26.805	4,284,000
1.22	8.88	2,175	33.327	14.437	3,132,000	2.33	12.25	3,000	62.916	27.253	4,320,000

12-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.07	25	.009	.004	36,000	.01	.85	300	.323	.140	432,000
	.14	50	.020	.009	72,000	.01	.92	325	.372	.161	468,000
	.21	75	.035	.015	108,000	.02	.99	350	.425	.184	504,000
	.28	100	.053	.023	144,000	.02	1.06	375	.481	.208	540,000
	.35	125	.075	.032	180,000	.02	1.13	400	.541	.234	576,000
	.43	150	.100	.043	216,000	.02	1.20	425	.603	.261	612,000
	.50	175	.129	.056	252,000	.03	1.28	450	.670	.290	648,000
	.57	200	.161	.070	288,000	.03	1.35	475	.740	.320	684,000
	.64	225	.196	.085	324,000	.03	1.42	500	.813	.352	720,000
	.71	250	.235	.102	360,000	.03	1.49	525	.890	.381	756,000
.01	.78	275	.277	.120	396,000	.04	1.56	550	.970	.420	792,000

12-Inch Pipe—Continued.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.04	1.63	575	1.053	.456	828,000	.38	4.96	1,750	8.862	3.839	2,520,000
.04	1.70	600	1.140	.494	864,000	.39	5.03	1,775	9.111	3.947	2,556,000
.05	1.77	625	1.231	.533	900,000	.41	5.11	1,800	9.363	4.056	2,592,000
.05	1.84	650	1.325	.574	936,000	.42	5.18	1,825	9.619	4.167	2,628,000
.06	1.91	675	1.422	.616	972,000	.43	5.25	1,850	9.878	4.279	2,664,000
.06	1.98	700	1.523	.660	1,008,000	.44	5.32	1,875	10.140	4.392	2,700,000
.07	2.05	725	1.627	.705	1,044,000	.45	5.39	1,900	10.406	4.508	2,736,000
.07	2.13	750	1.735	.752	1,080,000	.46	5.46	1,925	10.676	4.625	2,772,000
.07	2.20	775	1.846	.800	1,116,000	.48	5.53	1,950	10.948	4.742	2,808,000
.08	2.27	800	1.961	.849	1,152,000	.49	5.60	1,975	11.225	4.862	2,844,000
.09	2.34	825	2.079	.900	1,188,000	.50	5.67	2,000	11.504	4.998	2,880,000
.09	2.41	850	2.200	.953	1,224,000	.51	5.74	2,025	11.787	5.106	2,916,000
.10	2.48	875	2.325	1.007	1,260,000	.53	5.81	2,050	12.074	5.230	2,952,000
.10	2.55	900	2.453	1.062	1,296,000	.54	5.88	2,075	12.364	5.356	2,988,000
.11	2.62	925	2.585	1.120	1,332,000	.55	5.96	2,100	12.658	5.483	3,024,000
.11	2.69	950	2.720	1.178	1,368,000	.57	6.03	2,125	12.954	5.611	3,060,000
.12	2.76	975	2.859	1.238	1,404,000	.58	6.10	2,150	13.255	5.742	3,096,000
.13	2.84	1,000	3.001	1.300	1,440,000	.59	6.17	2,175	13.558	5.873	3,132,000
.13	2.91	1,025	3.146	1.363	1,476,000	.61	6.24	2,200	13.866	6.006	3,168,000
.14	2.98	1,050	3.295	1.427	1,512,000	.62	6.31	2,225	14.176	6.140	3,204,000
.14	3.05	1,075	3.448	1.494	1,548,000	.63	6.38	2,250	14.490	6.276	3,240,000
.15	3.12	1,100	3.603	1.561	1,584,000	.65	6.45	2,275	14.808	6.413	3,276,000
.16	3.19	1,125	3.763	1.630	1,620,000	.66	6.53	2,300	15.129	6.553	3,312,000
.17	3.26	1,150	3.925	1.700	1,656,000	.68	6.60	2,325	15.453	6.693	3,348,000
.17	3.33	1,175	4.092	1.773	1,692,000	.69	6.67	2,350	15.781	6.835	3,384,000
.18	3.40	1,200	4.261	1.846	1,728,000	.71	6.74	2,375	16.112	6.979	3,420,000
.19	3.47	1,225	4.434	1.921	1,764,000	.72	6.81	2,400	16.447	7.124	3,456,000
.20	3.54	1,250	4.611	1.997	1,800,000	.74	6.88	2,425	16.785	7.271	3,492,000
.20	3.61	1,275	4.791	2.075	1,836,000	.75	6.95	2,450	17.127	7.419	3,528,000
.21	3.69	1,300	4.974	2.155	1,872,000	.77	7.02	2,475	17.472	7.568	3,564,000
.22	3.76	1,325	5.161	2.233	1,908,000	.78	7.09	2,500	17.820	7.719	3,600,000
.23	3.83	1,350	5.351	2.318	1,944,000	.80	7.16	2,525	18.172	7.871	3,636,000
.24	3.90	1,375	5.545	2.402	1,980,000	.81	7.23	2,550	18.528	8.026	3,672,000
.25	3.97	1,400	5.742	2.487	2,016,000	.83	7.30	2,575	18.886	8.180	3,708,000
.25	4.04	1,425	5.942	2.574	2,052,000	.84	7.37	2,600	19.249	8.338	3,744,000
.26	4.11	1,450	6.146	2.662	2,088,000	.86	7.44	2,625	19.614	8.496	3,780,000
.27	4.18	1,475	6.354	2.752	2,124,000	.88	7.51	2,650	19.983	8.656	3,816,000
.28	4.25	1,500	6.565	2.844	2,160,000	.89	7.58	2,675	20.356	8.817	3,852,000
.29	4.32	1,525	6.779	2.936	2,196,000	.91	7.66	2,700	20.732	8.980	3,888,000
.30	4.39	1,550	6.997	3.031	2,232,000	.93	7.73	2,725	21.111	9.144	3,924,000
.31	4.46	1,575	7.218	3.127	2,268,000	.95	7.80	2,750	21.494	9.310	3,960,000
.32	4.54	1,600	7.442	3.224	2,304,000	.96	7.87	2,775	21.881	9.478	3,996,000
.33	4.61	1,625	7.671	3.323	2,340,000	.98	7.94	2,800	22.270	9.646	4,032,000
.34	4.68	1,650	7.902	3.423	2,376,000	1.00	8.01	2,825	22.663	9.817	4,068,000
.35	4.75	1,675	8.137	3.525	2,412,000	1.01	8.08	2,850	23.060	9.989	4,104,000
.36	4.82	1,700	8.375	3.628	2,448,000	1.03	8.15	2,875	23.460	10.162	4,140,000
.37	4.89	1,725	8.617	3.732	2,484,000	1.05	8.23	2,900	23.864	10.337	4,176,000

12-Inch Pipe—Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
1.07	8.30	2,925	24 271	10.514	4,212,000	1.32	9.22	3,250	29.874	12.940	4,680,000
1.09	8.37	2,950	24.681	10.691	4,248,000	1.34	9.29	3,275	30.329	13.138	4,716,000
1.11	8.44	2,975	25 095	10.870	4,284,000	1.36	9.36	3,300	30.788	13.336	4,752,000
1.13	8.51	3.000	25.512	11.051	4,320,000	1.38	9.43	3,325	31.250	13 536	4,788,000
1.15	8.58	3,025	25.933	11.233	4,356,000	1 40	9.50	3,350	31.715	13.738	4,824,000
1.17	8.65	3.050	26.357	11.417	4,392,000	1.42	9.57	3,375	32.184	13.942	4.860,000
1.18	8.72	3,075	26.785	11.603	4,428,000	1.45	9.64	3,400	32.656	14.145	4,896,000
1.20	8.79	3,100	27.216	11.789	4,464,000	1.47	9 71	3,425	33.132	14.352	4,932,000
1.22	8.86	3,125	27.650	11 978	4,500,000	1.49	9.78	3,450	33.611	14.560	4,968,000
1.24	8.93	3,150	28 088	12.167	4,536,000	1.51	9.85	3,475	34.094	14.769	5,004,000
1.26	9.00	3,175	28 529	12.358	4,572,000	1.53	9.93	3,500	34.580	14.979	5.040,000
1.28	9.08	3,200	28.974	12 550	4,608,000	1.56	10.00	3,525	35.069	15.191	5 076,000
1.30	9.15	3,225	29.422	12.745	4,644,000						

14-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.10	50	.012	.005	72.000	.17	3 33	1,600	3.510	1.520	2,304,000
	.21	100	.029	.013	144,000	.18	3.44	1.650	3.725	1.614	2,376,000
	.31	150	.053	.023	216.000	.20	3.54	1,700	3.946	1.709	2,448,000
	.42	200	.083	.036	288,000	.21	3.65	1.750	4.173	1.808	2,520,000
	.52	250	.119	.052	360,000	.22	3.75	1,800	4.407	1.909	2,592,000
	.63	300	.162	.070	432,000	.23	3.86	1,850	4.647	2.013	2,664,000
	.73	350	.211	.091	504,000	.24	3.96	1,900	4.894	2.118	2,736,000
.01	.83	400	.267	.116	576,000	.26	4.06	1,950	5.147	2.229	2,808,000
.01	.94	450	.329	.143	648,000	.27	4.17	2,000	5.406	2.342	2,880,000
.02	1.04	500	.397	.172	720,000	.28	4 27	2,050	5.672	2.457	2,952,000
.02	1.15	550	.472	.204	792,000	.30	4.38	2,100	5.944	2.575	3,024,000
.03	1.25	600	.553	.240	864 000	.31	4.48	2,150	6.222	2.695	3,096,000
.03	1.35	650	.640	.277	936,000	.33	4.59	2,200	6.507	2.818	3,168,000
.03	1.46	700	.734	.318	1.008,000	34	4.69	2.250	6.798	2.945	3,240,000
.04	1.56	750	.834	.362	1,080,000	.36	4.80	2,300	7.095	3.073	3,312,000
.04	1.67	800	.941	.408	1,152 000	.37	4.90	2,350	7.399	3.205	3,384,000
.05	1.77	850	1.053	.457	1,224.000	.39	5.00	2,400	7.709	3.339	3,456,000
.06	1.88	900	1 173	.508	1,296.000	.41	5.11	2,450	8.026	3.477	3,528,000
.06	1.98	950	1.298	.561	1,368.000	.42	5.21	2,500	8.349	3.617	3,600,000
.07	2.08	1,000	1.430	.619	1,440.000	.44	5.32	2.550	8.678	3.759	3,672,000
.07	2.18	1,050	1.568	.678	1,512,000	.46	5.42	2 600	9.014	3.905	3,744,000
.08	2.29	1,100	1.713	.742	1,584,000	.47	5.52	2,650	9.356	4.053	3,816,000
.09	2.39	1,150	1.864	.807	1,656,000	.49	5.63	2.700	9.704	4.204	3,888,000
.10	2.50	1,200	2.022	.876	1,728,000	.51	5.73	2,750	10.059	4.357	3,960,000
.11	2.60	1,250	2.185	.949	1.800.000	.53	5.84	2,800	10.420	4.514	4,032,000
.12	2.71	1,300	2.356	1.021	1,872,000	.55	5.94	2,850	10.788	4.673	4,104,000
.13	2.81	1,350	2.532	1.097	1,944,000	.57	6.05	2,900	11.161	4.835	4,176,000
.13	2.91	1,400	2.715	1.176	2,016,000	.59	6 15	2,950	11.542	5.000	4,248,000
.14	3.02	1,450	2.904	1.258	2,088,000	.61	6.25	3,000	11.928	5.167	4,320,000
.15	3.13	1,500	3.100	1.343	2,160,000	.63	6.36	3,050	12.321	5.337	4,392,000
.16	3.23	1,550	3.302	1.430	2,232,000	.65	6.46	3,100	12.721	5.510	4.464,000

14-Inch Pipe—Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.67	6.57	3,150	13.126	5.685	4,536,000	1.00	8.02	3,850	19.474	8.435	5,544,000
.69	6.67	3,200	13.538	5.864	4,608,000	1.03	8.13	3,900	19.975	8.653	5,616,000
.71	6.77	3,250	13.957	6.046	4,680,000	1.05	8.23	3,950	20.483	8.872	5,688,000
.74	6.88	3,300	14.381	6.229	4,752,000	1.08	8.34	4,000	20.997	9.095	5,760,000
.76	6.98	3,350	14.813	6.416	4,824,000	1.11	8.44	4,050	21.517	9.320	5,832,000
.78	7.09	3,400	15.250	6.607	4,896,000	1.13	8.54	4,100	22.044	9.549	5,904,000
.80	7.19	3,450	15.694	6.798	4,968,000	1.16	8.65	4,150	22.577	9.779	5,976,000
.83	7.29	3,500	16.144	6.993	5,040,000	1.19	8.75	4,200	23.116	10.013	6,048,000
.85	7.40	3,550	16.601	7.191	5,112,000	1.22	8.86	4,250	23.662	10.250	6,120,000
.87	7.50	3,600	17.064	7.392	5,184,000	1.25	8.96	4,300	24.214	10.488	6,192,000
.90	7.61	3,650	17.533	7.594	5,256,000	1.28	9.07	4,350	24.772	10.687	6,264,000
.92	7.71	3,700	18.009	7.800	5,328,000	1.31	9.17	4,400	25.337	10.975	6,336,000
.95	7.82	3,750	18.491	8.009	5,400,000	1.34	9.28	4,450	25.909	11.223	6,408,000
.98	7.92	3,800	18.979	8.221	5,472,000	1.37	9.38	4,500	26.486	11.473	6,480,000

16-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.08	50	.008	.003	72,000	.09	2.47	1,550	1.732	.750	2,232,000
	.16	100	.018	.008	144,000	.10	2.55	1,600	1.840	.797	2,304,000
	.24	150	.031	.013	216,000	.11	2.63	1,650	1.951	.845	2,376,000
	.32	200	.048	.021	288,000	.12	2.71	1,700	2.066	.895	2,448,000
	.40	250	.068	.029	360,000	.12	2.78	1,750	2.184	.946	2,520,000
	.48	300	.091	.039	432,000	.13	2.87	1,800	2.305	.999	2,592,000
	.56	350	.117	.051	504,000	.14	2.95	1,850	2.429	1.052	2,664,000
	.64	400	.147	.064	576,000	.14	3.03	1,900	2.557	1.108	2,736,000
	.72	450	.180	.078	648,000	.15	3.11	1,950	2.688	1.165	2,808,000
.01	.80	500	.216	.094	720,000	.16	3.19	2,000	2.822	1.222	2,880,000
.01	.88	550	.256	.111	792,000	.17	3.27	2,050	2.960	1.282	2,952,000
.01	.96	600	.299	.130	864,000	.17	3.35	2,100	3.100	1.343	3,024,000
.02	1.04	650	.345	.149	946,000	.18	3.43	2,150	3.244	1.405	3,096,000
.02	1.12	700	.394	.171	1,008,000	.19	3.51	2,200	3.392	1.469	3,168,000
.02	1.20	750	.447	.194	1,080,000	.20	3.59	2,250	3.542	1.534	3,240,000
.03	1.28	800	.502	.217	1,152,000	.21	3.67	2,300	3.696	1.601	3,312,000
.03	1.36	850	.562	.244	1,224,000	.22	3.75	2,350	3.853	1.669	3,384,000
.03	1.44	900	.624	.272	1,296,000	.23	3.83	2,400	4.013	1.738	3,456,000
.04	1.52	950	.690	.299	1,368,000	.24	3.91	2,450	4.177	1.809	3,528,000
.04	1.60	1.000	.758	.328	1,440,000	.25	3.99	2,500	4.344	1.882	3,600,000
.04	1.68	1.050	.831	.360	1,512,000	.26	4.07	2,550	4.514	1.995	3,672,000
.05	1.76	1.100	.906	.392	1,584,000	.27	4.15	2,600	4.687	2.030	3,744,000
.05	1.84	1.150	.985	.427	1,656,000	.28	4.23	2,650	4.864	2.107	3,816,000
.06	1.92	1.200	1.067	.462	1,728,000	.29	4.31	2,700	5.044	2.185	3,888,000
.06	2.00	1.250	1.152	.499	1,800,000	.30	4.39	2,750	5.227	2.264	3,960,000
.07	2.07	1.300	1.240	.537	1,872,000	.31	4.47	2,800	5.413	2.345	4,032,000
.07	2.15	1.350	1.332	.577	1,944,000	.32	4.55	2,850	5.603	2.427	4,104,000
.08	2.23	1.400	1.427	.618	2,016,000	.33	4.63	2,900	5.796	2.511	4,176,000
.08	2.31	1.450	1.525	.661	2,088,000	.35	4.71	2,950	5.992	2.596	4.248,000
.09	2.39	1.500	1.627	.705	2,160,000	.36	4.79	3,000	6.192	2.682	4,320,000

16-Inch Pipe—Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds					Feet.	Pounds.	
.37	4.87	3,050	6.395	2.770	4,392,000	.75	6.94	4,350	12.813	5.550	6,264,000
.38	4.95	3,100	6.601	2.859	4,464,000	.77	7.02	4,400	13.104	5.676	6,336,000
.39	5.03	3,150	6.810	2.949	4,536,000	.78	7.10	4,450	13.398	5.804	6,408,000
.41	5.11	3,200	7.023	3.042	4,608,000	.80	7.18	4 500	13.695	5.932	6,480,000
.42	5.19	3,250	7.238	3.135	4,680,000	.82	7.26	4 550	13.996	6.063	6,552,000
.43	5.27	3,300	7.457	3.230	4 752,000	.84	7.34	4,600	14.300	6.194	6.624,000
.44	5.35	3,350	7.680	3.327	4,824,000	.86	7.42	4.650	14.607	6.327	6.696,000
.46	5.43	3,400	7.905	3.424	4,896,000	.87	7.50	4,700	14.918	6.462	6,768,000
.47	5.51	3,450	8.134	3.523	4 968,000	.89	7.58	4,750	15.232	6.598	6,840,000
.49	5.59	3,500	8.367	3.625	5,040,000	.91	7.66	4,800	15.549	6.735	6,912,000
.50	5.67	3,550	8.602	3.726	5,112,000	.93	7.74	4,850	15.869	6.874	6,984,000
.51	5.75	3,600	8.841	3.830	5,184 000	.95	7.82	4,900	16.193	7.015	7,056,000
.53	5.83	3,650	9.083	3.935	5,256,000	.97	7.90	4,950	16.520	7.156	7,128,000
.54	5.91	3,700	9.328	4.041	5,328,000	.99	7.98	5,000	16.850	7.298	7,200,000
.56	5.99	3,750	9.576	4.148	5,400,000	1.01	8.06	5,050	17.183	7.434	7,272,000
.57	6.07	3,800	9.828	4.257	5,472,000	1.03	8.14	5,100	17.520	7.589	7,344,000
.59	6.15	3,850	10.083	4.368	5.544,000	1.05	8.22	5,150	17.860	7.736	7,416,000
.60	6.23	3,900	10.341	4.480	5,616,000	1.07	8.30	5,200	18.203	7.884	7,488,000
.62	6.31	3,950	10.603	4.593	5,688,000	1.09	8.38	5,250	18.549	8.033	7,560 000
.63	6.38	4,000	10.868	4.707	5,760,000	1.11	8.46	5,300	18.899	8.187	7,632,000
.65	6.46	4,050	11.136	4.824	5,832,000	1.13	8.54	5,350	19.252	8.340	7,704,000
.67	6.54	4,100	11.407	4.941	5,904,000	1.16	8.62	5,400	19.608	8.493	7,776,000
.68	6.62	4,150	11.682	5.060	5,976,000	1.18	8.70	5,450	19.968	8.649	7,848,000
.70	6.70	4,200	11.960	5.180	6,048,000	1.20	8.78	5,500	20.331	8.707	7,920,000
.72	6.78	4,250	12.241	5.303	6,120,000	1.22	8.86	5 550	20.697	8.965	7,992,000
.73	6.86	4,300	12.525	5.426	6,192,000	1.24	8.94	5,600	21.066	9.125	8,064,000

18-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.06	50	.005	.002	72,000	.02	1.19	950	.398	.172	1,368,000
	.13	100	.012	.005	144,000	.03	1.26	1,000	.437	.189	1,440,000
	.19	150	.020	.009	216,000	.03	1.32	1,050	.477	.204	1.512,000
	.25	200	.030	.013	288,000	.03	1.39	1,100	.520	.225	1 584,000
	.31	250	.042	.018	360,000	.03	1.45	1,150	.564	.244	1,656,000
	.38	300	.055	.024	432,000	.04	1.51	1,200	.611	.266	1,728,000
	.44	350	.071	.031	504,000	.04	1.58	1,250	.659	.285	1,800,000
	.50	400	.088	.038	576,000	.04	1.64	1,300	.709	.307	1,872,000
	.57	450	.107	.046	648,000	.05	1.70	1,350	.760	.329	1,944,000
	.63	500	.128	.055	720,000	.05	1.77	1,400	.814	.353	2,016,000
	.70	550	.151	.065	792,000	.05	1.83	1,450	.869	.376	2,088,000
	.76	600	.175	.076	864,000	.06	1.89	1,500	.926	.401	2,160,000
.01	.82	650	.202	.088	936.000	.06	1.95	1,550	.985	.427	2,232,000
.01	.88	700	.230	.100	1,008.000	.06	2.02	1,600	1.046	.453	2,304.000
.01	.94	750	.260	.113	1,080,000	.07	2.08	1,650	1.109	.480	2,376,000
.02	1.01	800	.291	.126	1,152,000	.07	2.14	1.700	1.173	.508	2,448 000
.02	1.07	850	.325	.141	1,224,000	.08	2.21	1,750	1.239	.537	2,520.000
.02	1.13	900	.360	.156	1,296,000	.08	2.27	1,800	1.307	.566	2,592,000

18-Inch Pipe - Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.09	2.33	1,850	1.377	.596	2,664,000	.44	5.30	4,200	6.702	2.903	6,048,000
.09	2.40	1,900	1.448	.627	2,736,000	.45	5.36	4,250	6.859	2.971	6,120,000
.09	2.46	1,950	1.522	.660	2,808,000	.46	5.43	4,300	7.017	3.040	6,192,000
.10	2.52	2,000	1.597	.692	2,880,000	.47	5.49	4,350	7.178	3.109	6,264,000
.10	2.58	2,050	1.674	.725	2,952,000	.48	5.55	4,400	7.340	3.179	6,336,000
.11	2.65	2,100	1.753	.759	3,024,000	.49	5.61	4,450	7.504	3.251	6,408,000
.11	2.71	2,150	1.834	.794	3,096,000	.50	5.67	4,500	7.670	3.322	6,480,000
.12	2.78	2,200	1.916	.830	3,168,000	.51	5.73	4,550	7.837	3.395	6,552,000
.13	2.84	2,250	2.000	.866	3,240,000	.52	5.79	4,600	8.007	3.468	6,624,000
.13	2.90	2,300	2.087	.904	3,312,000	.53	5.85	4,650	8.178	3.543	6,696,000
.14	2.96	2,350	2.175	.942	3,384,000	.54	5.91	4,700	8.351	3.617	6,768,000
.14	3.03	2,400	2.264	.981	3,456,000	.55	5.97	4,750	8.526	3.693	6,840,000
.15	3.09	2,450	2.356	1.021	3,528,000	.57	6.03	4,800	8.703	3.770	6,912,000
.15	3.15	2,500	2.449	1.061	3,600,000	.58	6.10	4,850	8.881	3.847	6,984,000
.16	3.21	2,550	2.544	1.102	3,672,000	.59	6.16	4,900	9.062	3.925	7,056,000
.17	3.27	2,600	2.641	1.144	3,744,000	.60	6.23	4,950	9.244	4.004	7,128,000
.17	3.34	2,650	2.740	1.187	3,816,000	.62	6.30	5,000	9.428	4.084	7,200,000
.18	3.40	2,700	2.841	1.231	3,888,000	.63	6.36	5,050	9.613	4.164	7,272,000
.19	3.47	2,750	2.943	1.275	3,960,000	.64	6.43	5,100	9.801	4.245	7,344,000
.19	3.53	2,800	3.047	1.320	4,032,000	.65	6.49	5,150	9.990	4.327	7,416,000
.20	3.59	2,850	3.154	1.366	4,104,000	.67	6.55	5,200	10.182	4.411	7,488,000
.21	3.66	2,900	3.261	1.413	4,176,000	.68	6.62	5,250	10.375	4.493	7,560,000
.22	3.72	2,950	3.371	1.460	4,248,000	.69	6.68	5,300	10.570	4.578	7,632,000
.22	3.78	3,000	3.483	1.509	4,320,000	.71	6.74	5,350	10.766	4.663	7,704,000
.23	3.85	3,050	3.596	1.558	4,392,000	.72	6.80	5,400	10.965	4.749	7,776,000
.24	3.91	3,100	3.711	1.607	4,464,000	.73	6.87	5,450	11.165	4.836	7,848,000
.24	3.97	3,150	3.828	1.658	4,536,000	.75	6.93	5,500	11.367	4.923	7,920,000
.25	4.03	3,200	3.947	1.710	4,608,000	.76	7.00	5,550	11.571	5.012	7,992,000
.26	4.10	3,250	4.067	1.762	4,680,000	.78	7.06	5,600	11.777	5.101	8,064,000
.27	4.16	3,300	4.189	1.815	4,752,000	.79	7.13	5,650	11.984	5.190	8,136,000
.28	4.22	3,350	4.314	1.874	4,824,000	.80	7.19	5,700	12.193	5.281	8,208,000
.29	4.29	3,400	4.440	1.923	4,896,000	.82	7.25	5,750	12.405	5.372	8,280,000
.29	4.35	3,450	4.567	1.978	4,968,000	.83	7.32	5,800	12.618	5.466	8,352,000
.30	4.41	3,500	4.697	2.034	5,040,000	.85	7.38	5,850	12.832	5.558	8,424,000
.31	4.48	3,550	4.828	2.091	5,112,000	.86	7.45	5,900	13.049	5.652	8,496,000
.32	4.54	3,600	4.962	2.148	5,184,000	.88	7.51	5,950	13.267	5.747	8,568,000
.33	4.61	3,650	5.097	2.208	5,256,000	.89	7.57	6,000	13.488	5.842	8,640,000
.34	4.67	3,700	5.234	2.267	5,328,000	.90	7.63	6,050	13.710	5.934	8,712,000
.35	4.73	3,750	5.372	2.327	5,400,000	.92	7.69	6,100	13.933	6.035	8,784,000
.36	4.80	3,800	5.513	2.388	5,472,000	.93	7.75	6,150	14.159	6.133	8,856,000
.37	4.86	3,850	5.655	2.450	5,544,000	.95	7.82	6,200	14.386	6.231	8,928,000
.38	4.92	3,900	5.799	2.512	5,616,000	.97	7.88	6,250	14.616	6.331	9,000,000
.39	4.98	3,950	5.945	2.575	5,688,000	.98	7.94	6,300	14.847	6.430	9,072,000
.40	5.04	4,000	6.093	2.639	5,760,000	1.00	8.01	6,350	15.080	6.532	9,144,000
.41	5.10	4,050	6.242	2.704	5,832,000	1.01	8.07	6,400	15.314	6.633	9,216,000
.42	5.17	4,100	6.394	2.770	5,904,000	1.03	8.13	6,450	15.551	6.736	9,288,000
.43	5.23	4,150	6.547	2.836	5,976,000	1.04	8.19	6,500	15.789	6.839	9,360,000

20-Inch Pipe—1,000 Feet Long.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds	
Less than 0.01 foot.	.05	50	.004	.002	72,000	.09	2.45	2.400	1.362	.590	3,456,000
	.10	100	.008	.003	144,000	.10	2.50	2,450	1.416	.613	3,528,000
	.15	150	.014	.006	216,000	.10	2.55	2,500	1.472	.638	3,600,000
	.20	200	.020	.009	288,000	.11	2.60	2,550	1.529	.662	3,672,000
	.25	250	.027	.012	360,000	.11	2.65	2,600	1.586	.687	3,744 000
	.31	300	.036	.016	432,000	.11	2.71	2,650	1.645	.713	3,816,000
	.36	350	.046	.020	504,000	.12	2.76	2,700	1.705	.739	3,888,000
	.41	400	.056	.024	576,000	.12	2.81	2,750	1.766	.765	3,960,000
	.46	450	.068	.029	648,000	.13	2.86	2,800	1.828	.792	4,032,000
	.51	500	.081	.035	720,000	.13	2.91	2,850	1.891	.819	4,104,000
	.56	550	.095	.041	792,000	.14	2.96	2,900	1.955	.847	4,176,000
	.61	600	.110	.048	864,000	.14	3.01	2,950	2.021	.875	4,248,000
	.66	650	.126	.055	936,000	.15	3.06	3,000	2.087	.904	4.320,000
	.71	700	.143	.062	1,008,000	.15	3.11	3,050	2.154	.933	4,392,000
	.77	750	.161	.070	1,080,000	.16	3.16	3,100	2.223	.963	4,464,000
.01	.82	800	.180	.078	1,152,000	.16	3.21	3,150	2.293	.993	4,536,000
.01	.87	850	.201	.087	1,224,000	.17	3.26	3,200	2.363	1.024	4.608,000
.01	.92	900	.222	.096	1,296,000	.17	3.31	3,250	2.435	1.055	4,680,000
.02	.97	950	.245	.106	1,368,000	.18	3.37	3,300	2.508	1.086	4,752,000
.02	1.02	1,000	.268	.116	1,440,000	.18	3.42	3,350	2.581	1.118	4,824,000
.02	1.07	1,050	.293	.127	1,512,000	.19	3.47	3,400	2.656	1.150	4.896,000
.02	1.12	1,100	.318	.138	1,584.000	.19	3.52	3,450	2.732	1.183	4,968,000
.02	1.17	1,150	.345	.149	1,656,000	.20	3.57	3,500	2.809	1.217	5,040,000
.02	1.22	1,200	.373	.162	1,728,000	.20	3.62	3,550	2.887	1.251	5,112,000
.03	1.27	1,250	.402	.174	1,800,000	.21	3.67	3,600	2.967	1.285	5,184,000
.03	1.33	1,300	.432	.187	1,872,000	.22	3.72	3,650	3.047	1.320	5,256,000
.03	1.38	1,350	.463	.200	1,944.000	.22	3.77	3,700	3.128	1.357	5,328,000
.03	1.43	1,400	.495	.214	2,016,000	.23	3.82	3,750	3.211	1.391	5,400,000
.03	1.48	1,450	.528	.229	2,088,000	.23	3.87	3,800	3.294	1.427	5,472 000
.04	1.53	1,500	.562	.243	2,160 000	.24	3.93	3,850	3.378	1.463	5,544,000
.04	1.58	1,550	.598	.259	2,232,000	.25	3.98	3,900	3.464	1.501	5,616,000
.04	1.63	1,600	.634	.275	2,304,000	.25	4.03	3,950	3.551	1.538	5,688,000
.04	1.68	1,650	.672	.291	2,376,000	.26	4.08	4,000	3.638	1.576	5,760,000
.05	1.74	1,700	.710	.308	2,448,000	.27	4.13	4,050	3.727	1.614	5,832,000
.05	1.79	1,750	.750	.325	2,520,000	.27	4.18	4,100	3.817	1.653	5,904,000
.05	1.84	1,800	.790	.342	2.592,000	.28	4.23	4,150	3.908	1.693	5,976,000
.06	1.89	1,850	.832	.360	2,664,000	.28	4.28	4,200	4.000	1.733	6,048,000
.06	1.94	1,900	.875	.379	2,736,000	.29	4.34	4,250	4.093	1.773	6,120,000
.06	1.99	1.950	.919	.398	2.808,000	.30	4.39	4,300	4.187	1.814	6,192,000
.06	2.04	2,000	.964	.417	2,880,000	.31	4.44	4,350	4.283	1.855	6,264,000
.07	2.09	2,050	1.010	.437	2,952,000	.31	4.49	4,400	4.379	1.893	6,336,000
.07	2.14	2,100	1.057	.458	3.024.000	.32	4.54	4,450	4.476	1.939	6,408,000
.07	2.19	2,150	1.105	.479	3,096,000	.33	4.59	4,500	4.575	1.982	6,480.000
.08	2.25	2,200	1.154	.500	3,168,000	.34	4.65	4,550	4.674	2.025	6,552,000
.08	2.30	2,250	1.204	.522	3,240,000	.34	4.70	4,600	4.775	2.068	6,624,000
.09	2.35	2,300	1.256	.544	3,312,000	.35	4.75	4,650	4.876	2.112	6,696,000
.09	2.40	2,350	1.308	.566	3.384,000	.36	4.80	4,700	4.979	2.157	6,768,000

20-Inch Pipe - Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.37	4.85	4,750	5.083	2.201	6,840,000	.61	6.28	6,150	8.423	3.649	8,856,000
.38	4.91	4,800	5.188	2.247	6,912,000	.62	6.33	6,200	8.558	3.707	8,928,000
.38	4.96	4,850	5.294	2.293	6,984,000	.63	6.38	6,250	8.694	3.766	9,000,000
.39	5.01	4,900	5.401	2.339	7,056,000	.64	6.44	6,300	8.831	3.825	9,072,000
.40	5.06	4,950	5.509	2.386	7,128,000	.65	6.49	6,350	8.969	3.885	9,144,000
.41	5.11	5,000	5.618	2.434	7,200,000	.66	6.54	6,400	9.108	3.945	9,216,000
.41	5.16	5,050	5.728	2.481	7,272,000	.68	6.59	6,450	9.248	4.006	9,288,000
.42	5.21	5,100	5.839	2.529	7,344,000	.69	6.64	6,500	9.390	4.068	9,360,000
.43	5.26	5,150	5.952	2.578	7,416,000	.70	6.69	6,550	9.532	4.130	9,432,000
.44	5.31	5,200	6.065	2.627	7,488,000	.71	6.74	6,600	9.675	4.191	9,504,000
.45	5.36	5,250	6.180	2.677	7,560,000	.72	6.79	6,650	9.820	4.254	9,576,000
.46	5.41	5,300	6.295	2.727	7,632,000	.73	6.85	6,700	9.965	4.317	9,648,000
.46	5.46	5,350	6.412	2.777	7,704,000	.74	6.90	6,750	10.112	4.380	9,720,000
.47	5.52	5,400	6.530	2.828	7,776,000	.75	6.95	6,800	10.259	4.444	9,792,000
.48	5.57	5,450	6.648	2.880	7,848,000	.76	7.00	6,850	10.408	4.509	9,864,000
.49	5.62	5,500	6.768	2.932	7,920,000	.77	7.05	6,900	10.558	4.574	9,936,000
.50	5.67	5,550	6.889	2.984	7,992,000	.78	7.10	6,950	10.709	4.639	10,008,000
.51	5.72	5,600	7.011	3.037	8,064,000	.79	7.15	7,000	10.861	4.705	10,080,000
.52	5.77	5,650	7.134	3.090	7,136,000	.81	7.20	7,050	11.014	4.771	10,152,000
.53	5.82	5,700	7.258	3.144	8,208,000	.82	7.25	7,100	11.168	4.838	10,224,000
.54	5.88	5,750	7.383	3.198	8,280,000	.83	7.30	7,150	11.323	4.905	10,296,000
.55	5.93	5,800	7.510	3.253	8,352,000	.84	7.35	7,200	11.479	4.972	10,368,000
.56	5.98	5,850	7.637	3.308	8,424,000	.85	7.40	7,250	11.637	5.041	10,440,000
.57	6.03	5,900	7.765	3.364	8,496,000	.86	7.46	7,300	11.795	5.109	10,512,000
.57	6.08	5,950	7.895	3.420	8,568,000	.88	7.51	7,350	11.954	5.178	10,584,000
.58	6.13	6,000	8.025	3.476	8,640,000	.89	7.56	7,400	12.115	5.248	10,656,000
.59	6.18	6,050	8.157	3.533	8,712,000	.90	7.61	7,450	12.276	5.318	10,728,000
.60	6.23	6,100	8.290	3.591	8,784,000	.91	7.66	7,500	12.439	5.388	10,800,000

24-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.03	50	.002	.001	72,000	Less than 0.01 foot.	.60	850	.089	.039	1,224,000
	.07	100	.005	.002	144,000		.64	900	.098	.042	1,296,000
	.10	150	.007	.003	216,000		.67	950	.108	.047	1,368,000
	.14	200	.010	.004	288,000		.71	1,000	.118	.051	1,440,000
	.17	250	.014	.006	360,000		.74	1,050	.128	.055	1,512,000
	.21	300	.018	.008	432,000		.78	1,100	.139	.060	1,584,000
	.24	350	.022	.010	504,000	.01	.81	1,150	.150	.065	1,656,000
	.28	400	.027	.012	576,000	.01	.85	1,200	.162	.070	1,728,000
	.31	450	.032	.014	648,000	.01	.88	1,250	.174	.075	1,800,000
	.35	500	.038	.016	720,000	.01	.92	1,300	.186	.081	1,872,000
	.39	550	.044	.019	792,000	.01	.95	1,350	.199	.086	1,944,000
	.43	600	.050	.022	864,000	.02	.99	1,400	.212	.092	2,016,000
	.46	650	.057	.025	936,000	.02	1.02	1,450	.226	.098	2,088,000
	.50	700	.064	.028	1,008,000	.02	1.06	1,500	.241	.104	2,160,000
	.53	750	.072	.031	1,080,000	.02	1.09	1,550	.255	.110	2,232,000
	.57	800	.080	.035	1,152,000	.02	1.13	1,600	.270	.117	2,304,000

24-Inch Pipe—Continued.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.02	1.16	1,650	.286	.124	2,376,000	.13	2.84	4,000	1.500	.650	5,760,000
.02	1.20	1,700	.302	.131	2,448,000	.13	2.87	4,050	1.536	.665	5,832,000
.02	1.24	1,750	.318	.138	2,520,000	.13	2.91	4,100	1.573	.681	5,904,000
.03	1.28	1,800	.335	.145	2,592,000	.13	2.94	4,150	1.610	.697	5,976,000
.03	1.31	1,850	.352	.152	2,664,000	.14	2.98	4,200	1.648	.714	6,048,000
.03	1.35	1,900	.370	.160	2,736,000	.14	3.01	4,250	1.686	.730	6,120,000
.03	1.38	1,950	.388	.168	2,808,000	.14	3.05	4,300	1.724	.747	6,192,000
.03	1.42	2,000	.406	.176	2,880,000	.15	3.08	4,350	1.763	.764	6,264,000
.03	1.45	2,050	.425	.184	2,952,000	.15	3.12	4,400	1.802	.781	6,336,000
.03	1.49	2,100	.445	.193	3,024,000	.15	3.15	4,450	1.841	.798	6,408,000
.04	1.52	2,150	.465	.201	3,096,000	.16	3.19	4 500	1.881	.815	6,480,000
.04	1.56	2,200	.485	.210	3,168,000	.16	3.23	4 550	1.922	.833	6,552,000
.04	1.59	2,250	.506	.219	3,240,000	.17	3.27	4,600	1.963	.850	6,624,000
.04	1.63	2,300	.527	.228	3,312,000	.17	3.30	4,650	2.004	.868	6,696,000
.04	1.67	2,350	.548	.237	3,384,000	.17	3.34	4,700	2.046	.887	6,768,000
.05	1.70	2,400	.570	.247	3,456,000	.18	3.37	4,750	2.088	.905	6,840,000
.05	1.73	2,450	.593	.257	3,528,000	.18	3.41	4,800	2.131	.923	6,912,000
.05	1.77	2,500	.615	.267	3,600,000	.18	3.44	4,850	2.174	.942	6,984,000
.05	1.80	2,550	.639	.278	3,672,000	.19	3.48	4,900	2.217	.960	7,056,000
.05	1.83	2,600	.662	.287	3,744,000	.19	3.51	4,950	2.261	.979	7,128,000
.05	1.87	2,650	.687	.298	3,816,000	.20	3.55	5,000	2.305	.999	7,200,000
.06	1.91	2,700	.711	.308	3,888,000	.20	3.58	5,050	2.350	1.018	7,272,000
.06	1.94	2,750	.736	.319	3,960,000	.21	3.62	5,100	2.395	1.038	7,344,000
.06	1.98	2,800	.761	.330	4,032,000	.21	3.65	5.150	2.441	1.057	7,416,000
.06	2.02	2,850	.787	.341	4,104,000	.21	3.69	5,200	2.487	1.077	7,488,000
.07	2.05	2,900	.814	.353	4,176,000	.22	3.72	5,250	2.533	1.097	7,560,000
.07	2.09	2,950	.840	.364	4,248,000	.22	3.76	5,300	2.580	1.118	7,632,000
.07	2.13	3,000	.867	.376	4,320,000	.22	3.79	5,350	2.628	1.138	7,704,000
.07	2.16	3,050	.895	.388	4,392,000	.23	3.83	5,400	2.675	1.159	7,776,000
.08	2.20	3,100	.923	.400	4,464,000	.23	3.86	5,450	2.724	1.180	7,848,000
.08	2.23	3,150	.951	.412	4,536,000	.24	3.90	5,500	2.772	1.201	7,920,000
.08	2.27	3,200	.980	.424	4,608,000	.24	3.93	5 550	2.821	1.222	7,992,000
.08	2.30	3,250	1.009	.437	4,680,000	.25	3.97	5,600	2.871	1.244	8,064,000
.09	2.34	3,300	1.039	.450	4,752,000	.25	4.00	5,650	2.921	1.265	8,136,000
.09	2.37	3,350	1.069	.463	4,824,000	.25	4.04	5,700	2.971	1.287	8,208,000
.09	2.41	3,400	1.100	.476	4,896,000	.26	4.08	5,750	3.022	1.309	8,280,000
.09	2.44	3,450	1.131	.490	4,968,000	.26	4.12	5,800	3.073	1.331	8,352,000
.10	2.48	3,500	1.162	.503	5,040,000	.27	4.15	5,850	3.125	1.354	8,424,000
.10	2.51	3,550	1.194	.517	5,112,000	.27	4.19	5,900	3.177	1.376	8,496,000
.10	2.55	3,600	1.227	.531	5,184,000	.28	4.22	5,950	3.229	1.399	8,568,000
.10	2.58	3,650	1.259	.545	5,256,000	.28	4.26	6,000	3.282	1.421	8,640,000
.11	2.62	3,700	1.292	.560	5,328,000	.29	4.29	6,050	3.336	1.444	8,712,000
.11	2.65	3,750	1.326	.575	5,400,000	.29	4.33	6,100	3.389	1.467	8,784,000
.11	2.69	3,800	1.360	.589	5,472,000	.30	4.36	6,150	3.444	1.492	8,856,000
.12	2.72	3,850	1.394	.604	5,544,000	.30	4.40	6,200	3.468	1.515	8,928,000
.12	2.76	3,900	1.429	.619	5,616,000	.31	4.43	6,250	3.553	1.539	9,000,000
.12	2.80	3,950	1.465	.635	5,688,000	.31	4.47	6,300	3.609	1.563	9,072,000

24-Inch Pipe—Concluded.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.32	4.50	6,350	3.665	1.588	9,144,000	.50	5.67	8,000	5.752	2.492	11,520,000
.32	4.54	6,400	3.721	1.612	9,216,000	.51	5.70	8,050	5.823	2.523	11,592,000
.33	4.57	6,450	3.778	1.636	9,288,000	.51	5.74	8,100	5.894	2.554	11,664,000
.33	4.61	6,500	3.835	1.661	9,360,000	.52	5.77	8,150	5.965	2.584	11,736,000
.34	4.64	6,550	3.893	1.686	9,432,000	.53	5.81	8,200	6.037	2.615	11,808,000
.34	4.68	6,600	3.951	1.712	9,504,000	.53	5.84	8,250	6.109	2.646	11,880,000
.35	4.71	6,650	4.010	1.737	9,576,000	.54	5.88	8,300	6.182	2.678	11,952,000
.35	4.75	6,700	4.068	1.762	9,648,000	.54	5.91	8,350	6.255	2.711	12,024,000
.36	4.78	6,750	4.128	1.786	9,720,000	.55	5.95	8,400	6.329	2.745	12,096,000
.36	4.82	6,800	4.188	1.813	9,792,000	.56	5.98	8,450	6.403	2.774	12,168,000
.37	4.85	6,850	4.248	1.840	9,864,000	.56	6.02	8,500	6.477	2.806	12,240,000
.37	4.89	6,900	4.309	1.867	9,936,000	.57	6.06	8,550	6.552	2.839	12,312,000
.38	4.92	6,950	4.370	1.893	10,008,000	.58	6.10	8,600	6.627	2.872	12,384,000
.38	4.96	7,000	4.431	1.919	10,080,000	.58	6.13	8,650	6.703	2.905	12,456,000
.39	4.99	7,050	4.493	1.946	10,152,000	.59	6.17	8,700	6.779	2.938	12,528,000
.39	5.03	7,100	4.556	1.974	10,224,000	.60	6.20	8,750	6.856	2.971	12,600,000
.40	5.06	7,150	4.618	2.000	10,296,000	.61	6.24	8,800	6.933	3.004	12,672,000
.40	5.10	7,200	4.682	2.028	10,368,000	.61	6.27	8,850	7.010	3.037	12,744,000
.41	5.13	7,250	4.745	2.056	10,440,000	.62	6.31	8,900	7.088	3.070	12,816,000
.42	5.17	7,300	4.809	2.084	10,512,000	.63	6.34	8,950	7.166	3.103	12,888,000
.42	5.20	7,350	4.874	2.112	10,584,000	.63	6.38	9,000	7.245	3.137	12,960,000
.43	5.24	7,400	4.939	2.140	10,656,000	.64	6.41	9,050	7.324	3.171	13,032,000
.43	5.27	7,450	5.004	2.168	10,728,000	.65	6.45	9,100	7.404	3.206	13,104,000
.44	5.31	7,500	5.070	2.197	10,800,000	.66	6.49	8,150	7.484	3.241	13,176,000
.44	5.34	7,550	5.136	2.225	10,872,000	.66	6.53	9,200	7.564	3.276	13,248,000
.45	5.38	7,600	5.203	2.254	10,944,000	.67	6.56	9,250	7.645	3.311	13,320,000
.46	5.42	7,650	5.270	2.282	11,016,000	.68	6.60	9,300	7.727	3.346	13,392,000
.46	5.46	7,700	5.338	2.311	11,088,000	.68	6.63	9,350	7.808	3.382	13,464,000
.47	5.49	7,750	5.406	2.341	11,160,000	.69	6.67	9,400	7.890	3.418	13,536,000
.48	5.53	7,800	5.474	2.371	11,232,000	.70	6.70	9,450	7.973	3.454	13,608,000
.48	5.56	7,850	5.543	2.401	11,304,000	.71	6.74	9,500	8.056	3.490	13,680,000
.49	5.60	7,900	5.612	2.431	11,376,000	.71	6.77	9,550	8.140	3.526	13,752,000
.49	5.63	7,950	5.682	2.461	11,448,000	.72	6.81	9,600	8.223	3.562	13,824,000

30-Inch Pipe—1,000 Feet Long.

Less than 0.01 foot.	.04	100	.002	.001	144,000	Less than 0.01 foot.	.54	1,200	.060	.026	1,728,000
	.09	200	.005	.002	288,000		.59	1,300	.069	.030	1,872,000
	.14	300	.008	.003	432,000		.63	1,400	.078	.034	2,016,000
	.18	400	.011	.005	576,000		.68	1,500	.088	.038	2,160,000
	.23	500	.015	.006	720,000		.73	1,600	.098	.042	2,304,000
	.27	600	.020	.009	864,000		.77	1,700	.109	.047	2,448,000
	.32	700	.025	.011	1,008,000	.01	.82	1,800	.120	.052	2,592,000
	.36	800	.031	.013	1,152,000	.01	.86	1,900	.132	.057	2,736,000
	.41	900	.038	.016	1,296,000	.01	.91	2,000	.145	.063	2,880,000
	.45	1,000	.044	.019	1,440,000	.01	.95	2,100	.158	.068	3,024,000
	.50	1,100	.052	.023	1,584,000	.02	1.00	2,200	.172	.074	3,168,000

30-Inch Pipe—Continued.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.02	1.04	2,300	.186	.081	3,312,000	.16	3.18	7,000	1.492	.646	10,080,000
.02	1.09	2,400	.201	.087	3,456,000	.16	3.22	7,100	1.534	.664	10,224,000
.02	1.13	2,500	.216	.094	3,600,000	.17	3.27	7,200	1.575	.682	10,368,000
.02	1.18	2,600	.232	.100	3,744,000	.17	3.31	7,300	1.618	.701	10,512,000
.02	1.22	2,700	.249	.108	3,888,000	.18	3.36	7,400	1.661	.719	10,656,000
.03	1.27	2,800	.266	.115	4,032,000	.18	3.40	7,500	1.704	.738	10,800,000
.03	1.32	2,900	.283	.123	4,176,000	.19	3.45	7,600	1.749	.758	10,944,000
.03	1.36	3,000	.302	.131	4,320,000	.19	3.49	7,700	1.793	.777	11,088,000
.03	1.41	3,100	.320	.139	4,464.000	.19	3.53	7,800	1.839	.797	11,232,000
.03	1.45	3,200	.340	.147	4,608 000	.20	3.58	7,900	1.884	.816	11,376,000
.04	1.50	3,300	.360	.156	4,752.000	.21	3.63	8,000	1.931	.836	11,520,000
.04	1.54	3,400	.380	.165	4,896,000	.21	3.67	8,100	1.978	.857	11,664,000
.04	1.59	3,500	.401	.174	5,040,000	.22	3.72	8,200	2.025	.877	11,808,000
.04	1.63	3,600	.423	.184	5,184,000	.22	3.76	8,300	2.073	.898	11,952,000
.04	1.68	3,700	.445	.193	5,328,000	.23	3.81	8,400	2.122	.919	12,096,000
.05	1.72	3,800	.468	.203	5,472,000	.23	3.86	8,500	2.171	.941	12,240,000
.05	1.77	3,900	.491	.213	5,616,000	.24	3.90	8,600	2.221	.962	12,384,000
.05	1.82	4,000	.515	.223	5,760,000	.24	3.95	8,700	2.271	.984	12,528,000
.05	1.86	4,100	.539	.234	5,904,000	.25	3.99	8,800	2.322	1.006	12,672,000
.06	1.91	4,200	.564	.244	6,048,000	.25	4.03	8,900	2.374	1.028	12,816,000
.06	1.95	4,300	.590	.255	6,192,000	.26	4.08	9,000	2.426	1.051	12,960,000
.06	2.00	4,400	.616	.266	6,336,000	.26	4.12	9,100	2.478	1.073	13,104,000
.06	2.04	4,500	.642	.278	6,480,000	.27	4.17	9,200	2.531	1.096	13,248,000
.07	2.09	4,600	.670	.290	6,624,000	.28	4.21	9,300	2.585	1.120	13,392,000
.07	2.13	4,700	.697	.302	6,768,000	.28	4.26	9,400	2.639	1.143	13,536,000
.07	2.17	4,800	.726	.314	6,912,000	.29	4.30	9,500	2.694	1.167	13,680,000
.08	2.22	4,900	.755	.327	7,056,000	.29	4.35	9,600	2.750	1.191	13,824,000
.08	2.27	5,000	.784	.340	7,200,000	.30	4.40	9,700	2.806	1.216	13,968,000
.08	2.31	5,100	.814	.353	7,344,000	.31	4.44	9,800	2.862	1.240	14,112,000
.09	2.36	5,200	.845	.366	7,488,000	.31	4.49	9,900	2.919	1.264	14,256,000
.09	2.40	5,300	.876	.379	7,632,000	.32	4.54	10,000	2.977	1.289	14,400,000
.09	2.45	5,400	.908	.393	7,776,000	.33	4.58	10,100	3.035	1.314	14,544,000
.10	2.50	5,500	.940	.407	7,920,000	.33	4.63	10,200	3.094	1.340	14,688,000
.10	2.54	5,600	.973	.421	8,064,000	.34	4.67	10,300	3.153	1.366	14,832,000
.10	2.59	5,700	1.006	.436	8,208,000	.35	4.72	10,400	3.213	1.392	14,976,000
.11	2.63	5,800	1.040	.451	8,352,000	.35	4.77	10,500	3.274	1.418	15,120,000
.11	2.67	5,900	1.075	.466	8,496,000	.36	4.82	10,600	3.335	1.445	15,264,000
.12	2.72	6,000	1.110	.481	8,640,000	.37	4.86	10,700	3.396	1.471	15,408,000
.12	2.76	6,100	1.145	.496	8,784,000	.38	4.91	10,800	3.459	1.498	15,552,000
.12	2.81	6,200	1.182	.512	8,928,000	.38	4.95	10,900	3.521	1.525	15,696,000
.13	2.85	6,300	1.219	.528	9,072,000	.39	5.00	11,000	3.585	1.553	15,840,000
.13	2.90	6,400	1.256	.544	9,216,000	.40	5.04	11,100	3.648	1.580	15,984,000
.14	2.95	6,500	1.294	.561	9,360,000	.40	5.09	11,200	3.713	1.608	16,128,000
.14	2.99	6,600	1.332	.577	9,504,000	.41	5.13	11,300	3.778	1.637	16,272,000
.14	3.04	6,700	1.372	.594	9,648,000	.42	5.18	11,400	3.843	1.665	16,416,000
.15	3.08	6,800	1.411	.611	9,792,000	.42	5.22	11,500	3.909	1.693	16,560,000
.15	3.13	6,900	1.451	.629	9,936,000	.43	5.27	11,600	3.976	1.722	16,704,000

30-Inch Pipe—Concluded.

Head in feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.44	5.31	11,700	4.043	1.751	16,848,000	.58	6.08	13,400	5.273	2.284	19,296,000
.45	5.36	11,800	4.111	1.781	16,992,000	.58	6.13	13,500	5.350	2.317	19,440,000
.45	5.40	11,900	4.180	1.811	17,136,000	.59	6.17	13,600	5.428	2.351	19,584,000
.46	5.44	12,000	4.249	1.841	17,280,000	.60	6.22	13,700	5.507	2.385	19,728,000
.47	5.48	12,100	4.318	1.870	17,424,000	.61	6.26	13,800	5.586	2.420	19,872,000
.48	5.53	12,200	4.388	1.900	17,568,000	.62	6.31	13,900	5.665	2.454	20,016,000
.48	5.57	12,300	4.459	1.931	17,712,000	.63	6.36	14,000	5.746	2.489	20,160,000
.49	5.62	12,400	4.530	1.962	17,856,000	.64	6.40	14,100	5.826	2.524	20,304,000
.50	5.66	12,500	4.602	1.993	18,000,000	.65	6.45	14,200	5.908	2.559	20,448,000
.51	5.71	12,600	4.674	2.024	18,144,000	.66	6.49	14,300	5.990	2.595	20,592,000
.51	5.75	12,700	4.747	2.056	18,288,000	.67	6.54	14,400	6.072	2.630	20,736,000
.52	5.80	12,800	4.820	2.088	18,432,000	.67	6.58	14,500	6.155	2.666	20,880,000
.53	5.85	12,900	4.894	2.120	18,576,000	.68	6.63	14,600	6.239	2.702	21,024,000
.54	5.90	13,000	4.969	2.152	18,720,900	.69	6.67	14,700	6.323	2.739	21,168,000
.55	5.94	13,100	5.044	2.185	18,864,000	.70	6.72	14,800	6.408	2.776	21,312,000
.56	5.99	13,200	5.120	2.217	19,008,000	.71	6.76	14,900	6.493	2.813	21,456,000
.57	6.04	13,300	5.196	2.250	19,152,000	.72	6.80	15,000	6.579	2.850	21,600,000

36-Inch Pipe—1,000 Feet Long.

	.032	100	.001	.000	144,000	.01	.882	2,800	.115	.050	4,032,000
	.063	200	.003	.001	288,000	.01	.913	2,900	.122	.053	4,176,000
	.095	300	.004	.002	432,000	.01	.945	3,000	.130	.056	4,320,000
	.126	400	.006	.003	576,000	.02	.977	3,100	.138	.060	4,464,000
	.158	500	.008	.004	720,000	.02	1.009	3,200	.146	.063	4,608,000
	.189	600	.010	.004	864,000	.02	1.040	3,300	.154	.067	4,752,000
	.221	700	.012	.005	1,008,000	.02	1.072	3,400	.163	.071	4,896,000
	.252	800	.015	.006	1,152,000	.02	1.103	3,500	.171	.074	5,040,000
	.284	900	.018	.008	1,296,000	.02	1.135	3,600	.180	.078	5,184,000
	.315	1,000	.021	.009	1,440,000	.02	1.167	3,700	.189	.082	5,328,000
	.346	1,100	.024	.010	1,584,000	.02	1.198	3,800	.199	.086	5,472,000
	.378	1,200	.028	.012	1,728,000	.02	1.234	3,900	.208	.090	5,616,000
	.409	1,300	.031	.013	1,872,000	.03	1.260	4,000	.218	.094	5,760,000
	.440	1,400	.035	.015	2,016,000	.03	1.291	4,100	.228	.099	5,904,000
	.472	1,500	.040	.017	2,160,000	.03	1.323	4,200	.239	.104	6,048,000
	.503	1,600	.044	.019	2,304,000	.03	1.355	4,300	.249	.108	6,192,000
	.535	1,700	.049	.021	2,448,000	.03	1.386	4,400	.260	.113	6,336,000
	.566	1,800	.054	.023	2,592,000	.03	1.418	4,500	.271	.117	6,480,000
	.597	1,900	.059	.026	2,736,000	.03	1.449	4,600	.282	.122	6,624,000
	.630	2,000	.064	.028	2,880,000	.03	1.481	4,700	.294	.127	6,768,000
	.661	2,100	.070	.030	3,024,000	.04	1.512	4,800	.305	.132	6,912,000
	.693	2,200	.075	.032	3,168,000	.04	1.544	4,900	.317	.138	7,056,000
	.724	2,300	.081	.035	3,312,000	.04	1.576	5,000	.329	.143	7,200,000
	.756	2,400	.088	.038	3,456,000	.04	1.608	5,100	.342	.149	7,344,000
	.787	2,500	.094	.041	3,600,000	.04	1.639	5,200	.354	.154	7,488,000
.01	.819	2,600	.101	.044	3,744,000	.04	1.671	5,300	.367	.160	7,632,000
.01	.850	2,700	.108	.047	3,888,000	.05	1.702	5,400	.380	.165	7,776,000

Less than 0.01 foot.

36-Inch Pipe—Continued.

Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.05	1.734	5,500	.393	.170	7,920,000	.16	3.21	10,200	1.272	.55	14,688,000
.05	1.765	5,600	.407	.176	8,064,000	.16	3.24	10,300	1.296	.56	14,832,000
.05	1.797	5,700	.421	.182	8,208,000	.17	3.28	10,400	1.321	.57	14,976,000
.05	1.828	5,800	.435	.188	8,352,000	.17	3.31	10,500	1.345	.58	15,120,000
.05	1.86	5,900	.449	.194	8,496,000	.17	3.34	10,600	1.370	.59	15,264,000
.06	1.89	6,000	.463	.201	8,640,000	.18	3.37	10,700	1.395	.60	15,408,000
.06	1.92	6,100	.478	.207	8,784,000	.18	3.40	10,800	1.420	.62	15,552,000
.06	1.95	6,200	.493	.214	8,928,000	.18	3.43	10,900	1.446	.63	15,696,000
.06	1.98	6,300	.508	.220	9,072,000	.19	3.46	11,000	1.472	.64	15,840,000
.06	2.02	6,400	.523	.227	9,216,000	.19	3.50	11,100	1.498	.65	15,984,000
.07	2.05	6,500	.538	.233	9,360,000	.19	3.53	11,200	1.524	.66	16,128,000
.07	2.08	6,600	.554	.240	9,504,000	.20	3.56	11,300	1.550	.67	16,272,000
.07	2.11	6,700	.570	.247	9,648,000	.20	3.60	11,400	1.577	.68	16,416,000
.07	2.14	6,800	.586	.254	9,792,000	.20	3.63	11,500	1.604	.69	16,560,000
.07	2.17	6,900	.603	.261	9,936,000	.21	3.66	11,600	1.631	.71	16,704,000
.08	2.21	7,000	.619	.269	10,080,000	.21	3.69	11,700	1.658	.72	16,848,000
.08	2.24	7,100	.636	.276	10,224,000	.22	3.72	11,800	1.686	.73	16,992,000
.08	2.27	7,200	.653	.283	10,368,000	.22	3.75	11,900	1.713	.74	17,136,000
.08	2.30	7,300	.671	.291	10,512,000	.22	3.78	12,000	1.741	.75	17,280,000
.09	2.34	7,400	.688	.298	10,656,000	.23	3.81	12,100	1.769	.77	17,424,000
.09	2.37	7,500	.706	.306	10,800,000	.23	3.84	12,200	1.798	.78	17,568,000
.09	2.40	7,600	.724	.313	10,944,000	.23	3.87	12,300	1.827	.79	17,712,000
.09	2.43	7,700	.742	.321	11,088,000	.24	3.91	12,400	1.855	.81	17,856,000
.09	2.46	7,800	.761	.329	11,232,000	.24	3.94	12,500	1.885	.82	18,000,000
.10	2.49	7,900	.780	.337	11,376,000	.25	3.97	12,600	1.914	.83	18,144,000
.10	2.52	8,000	.798	.346	11,520,000	.25	4.00	12,700	1.943	.84	18,288,000
.10	2.55	8,100	.818	.354	11,664,000	.25	4.03	12,800	1.973	.85	18,432,000
.10	2.58	8,200	.837	.363	11,808,000	.26	4.06	12,900	2.003	.87	18,576,000
.11	2.61	8,300	.857	.371	11,952,000	.26	4.09	13,000	2.033	.88	18,720,000
.11	2.65	8,400	.877	.380	12,096,000	.27	4.13	13,100	2.064	.89	18,864,000
.11	2.68	8,500	.897	.389	12,240,000	.27	4.16	13,200	2.095	.91	19,008,000
.11	2.71	8,600	.917	.397	12,384,000	.27	4.19	13,300	2.126	.92	19,152,000
.12	2.74	8,700	.937	.406	12,528,000	.28	4.23	13,400	2.157	.94	19,296,000
.12	2.77	8,800	.958	.415	12,672,000	.28	4.26	13,500	2.188	.95	19,440,000
.12	2.80	8,900	.979	.424	12,816,000	.29	4.29	13,600	2.220	.96	19,584,000
.13	2.84	9,000	1.000	.433	12,960,000	.29	4.32	13,700	2.252	.97	19,728,000
.13	2.87	9,100	1.022	.443	13,104,000	.29	4.35	13,800	2.284	.99	19,872,000
.13	2.90	9,200	1.043	.452	13,248,000	.30	4.38	13,900	2.316	1.00	20,016,000
.13	2.93	9,300	1.065	.461	13,392,000	.30	4.41	14,000	2.348	1.02	20,160,000
.14	2.97	9,400	1.087	.471	13,536,000	.31	4.44	14,100	2.381	1.03	20,304,000
.14	3.00	9,500	1.110	.481	13,680,000	.31	4.47	14,200	2.414	1.04	20,448,000
.14	3.03	9,600	1.132	.490	13,824,000	.32	4.50	14,300	2.447	1.06	20,592,000
.15	3.06	9,700	1.155	.500	13,968,000	.32	4.54	14,400	2.481	1.07	20,736,000
.15	3.09	9,800	1.178	.51	14,112,000	.32	4.57	14,500	2.514	1.09	20,880,000
.15	3.12	9,900	1.201	.52	14,256,000	.33	4.60	14,600	2.548	1.10	21,024,000
.15	3.15	10,000	1.225	.53	14,400,000	.33	4.63	14,700	2.582	1.12	21,178,000
.16	3.18	10,100	1.248	.54	14,544,000	.34	4.66	14,800	2.617	1.13	21,312,000

36-Inch Pipe—Concluded.

Head in feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.	Head in Feet required to produce Velocity.	Velocity in Pipe in Feet per Second.	U. S. Gallons discharged per Minute.	FRICTION HEAD.		U. S. Gallons discharged per twenty-four Hours.
			Feet.	Pounds.					Feet.	Pounds.	
.34	4.69	14,900	2.651	1.15	21,456,000	.47	5.52	17,500	3.629	1.57	25,200,000
.35	4.73	15,000	2.686	1.17	21,600,000	.48	5.55	17,600	3.670	1.59	25,344,000
.35	4.76	15,100	2.721	1.18	21,744,000	.48	5.58	17,700	3.711	1.61	25,488,000
.36	4.79	15,200	2.756	1.20	21,888,000	.49	5.61	17,800	3.752	1.63	25,632,000
.36	4.82	15,300	2.792	1.21	22,032,000	.49	5.64	17,900	3.793	1.64	25,776,000
.37	4.86	15,400	2.827	1.23	22,176,000	.50	5.68	18,000	3.835	1.66	25,920,000
.37	4.89	15,500	2.863	1.24	22,320,000	.51	5.71	18,100	3.877	1.68	26,064,000
.38	4.93	15,600	2.899	1.26	22,464,000	.51	5.74	18,200	3.919	1.70	26,208,000
.38	4.96	15,700	2.936	1.27	22,608,000	.52	5.77	18,300	3.961	1.72	26,352,000
.39	4.99	15,800	2.972	1.29	22,752,000	.53	5.81	18,400	4.003	1.73	26,496,000
.39	5.02	15,900	3.009	1.30	22,896,000	.53	5.84	18,500	4.046	1.75	26,640,000
.40	5.05	16,000	3.046	1.32	23,040,000	.54	5.87	18,600	4.089	1.77	26,784,000
.40	5.08	16,100	3.084	1.34	23,184,000	.54	5.90	18,700	4.132	1.79	26,928,000
.41	5.11	16,200	3.121	1.35	23,328,000	.55	5.93	18,800	4.176	1.81	27,072,000
.41	5.14	16,300	3.159	1.37	23,472,000	.55	5.96	18,900	4.219	1.83	27,216,000
.42	5.18	16,400	3.197	1.38	23,616,000	.56	5.99	19,000	4.263	1.85	27,360,000
.42	5.21	16,500	3.235	1.40	23,760,000	.56	6.02	19,100	4.307	1.87	27,504,000
.43	5.24	16,600	3.273	1.42	23,904,000	.57	6.05	19,200	4.351	1.89	27,648,000
.43	5.27	16,700	3.312	1.44	24,048,000	.57	6.08	19,300	4.396	1.91	27,792,000
.44	5.30	16,800	3.351	1.45	24,192,000	.58	6.12	19,400	4.441	1.92	27,936,000
.44	5.33	16,900	3.390	1.47	24,336,000	.59	6.15	19,500	4.486	1.94	28,080,000
.45	5.36	17,000	3.429	1.49	24,480,000	.59	6.18	19,600	4.531	1.96	28,224,000
.45	5.39	17,100	3.469	1.51	24,624,000	.60	6.21	19,700	4.576	1.98	28,368,000
.46	5.42	17,200	3.508	1.52	24,768,000	.61	6.24	19,800	4.622	2.00	28,512,000
.46	5.45	17,300	3.548	1.54	24,912,000	.61	6.27	19,900	4.668	2.02	28,656,000
.47	5.49	17,400	3.589	1.56	25,056,000	.62	6.30	20,000	4.714	2.04	28,800,000

FRICTION HEADS FOR ELBOWS.

HEADS REQUIRED TO OVERCOME THE RESISTANCE OF NINETY DEGREE CIRCULAR BENDS.

Velocity in Feet Per Second.	Radius of Bend in Diameters of Pipe.							
	0.5	0.75	1.00	1.25	1.5	2.0	3.0	5.0
	Head, in Feet.							
1	.016	.005	.002	.002	.001	.001	.001	.001
2	.062	.018	.009	.007	.005	.005	.004	.004
3	.140	.041	.020	.015	.012	.011	.010	.009
4	2.24	.072	.036	.026	.021	.019	.017	.016
5	.388	.113	.056	.041	.033	.029	.027	.025
6	.559	.162	081	.059	.048	.042	.038	.036
7	.761	.221	.110	.080	.066	.057	.052	.050
8	.994	.288	.114	.104	.086	.074	.069	.065
9	1.260	.365	.182	.132	.108	.094	.086	.082
10	1.550	.450	.225	.163	.134	.116	.106	.101
12	2.240	.649	.324	.	.192	.167	.153	.145

The above table has been calculated by the well known Weisbach formula, for pipes or bends of circular cross section, i. e., round water pipe specials.

Let R = radius of curve or bend in inches.
r = radius of section of pipe in inches.
K = coefficient of resistance.
v = velocity of flow in feet per second.
a° = angle embraced by curve or bend (a right angle bend = 90°.)
h = friction head in feet or decimal of foot.
g = acceleration due to gravity = 32.2.

Then

$$K = 0.131 + 1.847\left\{\frac{r}{R}\right\}^{\frac{7}{2}}$$

And

$$h = K \frac{v^2}{2g} \times \frac{a^\circ}{180}$$

Suppose a 90° bend of circular cross section, 20 inches diameter (r = 10) and 25 inches radius of curvature (= R.) what friction head is developed by a velocity of flow of 2.7896 feet per second ?

$$K = 0.131 + 1.847\left\{\frac{10}{25}\right\}^{\frac{7}{2}} = 0.206$$

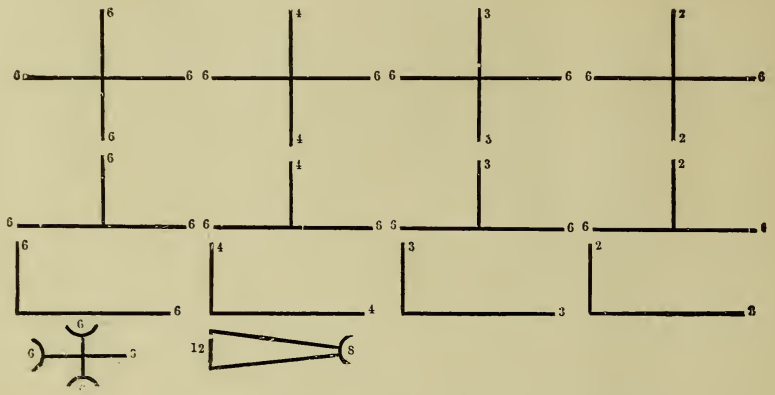
And

$$h. = .206 \frac{2,7896^2}{64.4} \times \frac{90}{180} = 0.01245 \text{ ft.}$$

DIRECTIONS WHEN ORDERING PIPE AND SPECIALS.

When inquiring price of, or ordering pipe, be careful and explicit in stating—first, the size; second, whether for gas or water; third, weight per foot; fourth, quantity of each size required.

Crosses, Tees, and Elbows are specified as follows:

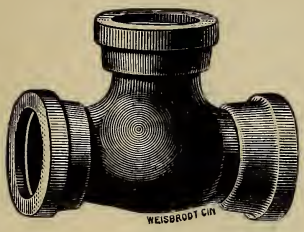


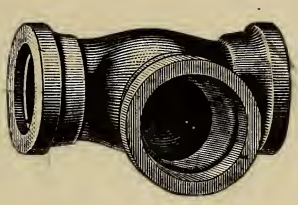
For any pattern out of the ordinary line, more explicit directions should be given by marking on the cross or tee where socket and spigot ends are required, as above: This would be three 6-inch outlets with sockets, and one with spigot. Where no such instructions are given, the outlets are supposed to be all sockets. Drawings should accompany all orders for anything requiring special patterns of unusual forms.

For reducers give the diameter at each end, and also state whether a socket or a spigot end is desired, as shown above: this being a reducer from 12 to 8 with the socket on the small end. A socket is always cast on the small end of reducers and a spigot on the other, unless the contrary is specified.

One-eighth or one-quarter bends may be ordered by giving merely the diameter of pipe required.

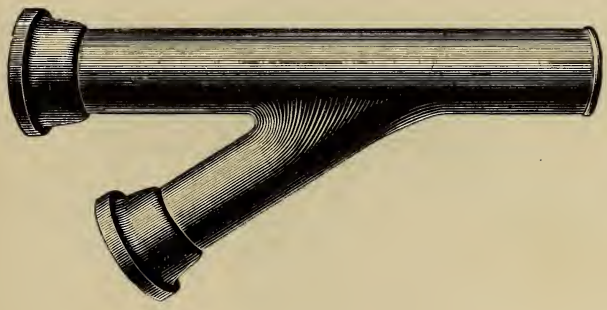
We append engravings of branch castings as manufactured by us. Our branches vary in size from 2 to 60 inches.



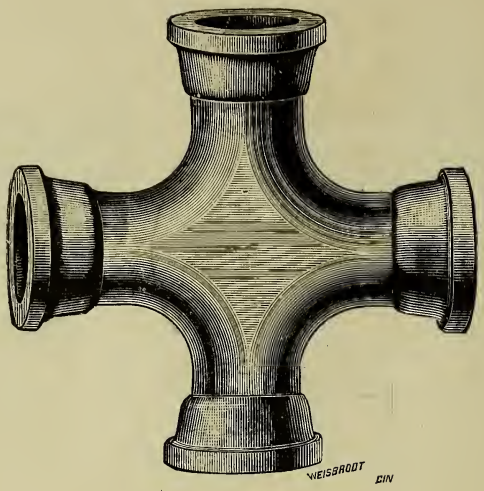


Our smaller specials are now made as shown in the above cuts. The curved sides not only allow freer water-way, thus overcoming the excessive friction that is caused by small specials, but also insure a more perfect casting, as any extraneous matter in the iron can more readily escape from the mold.

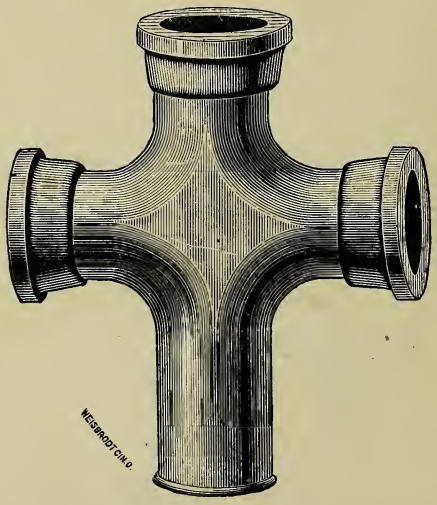
The tee is utilized to make a single branch at right angles to the main.



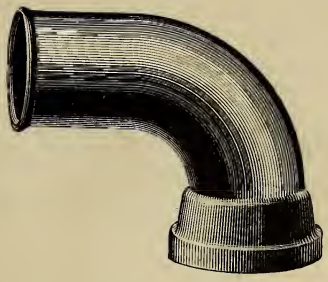
Branch pipes are to connect mains which are at a slight angle to each other.



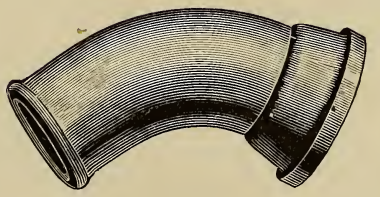
Crosses are placed at the intersection of streets or other points on the line of pipe where it is desired to extend branches at right angles.



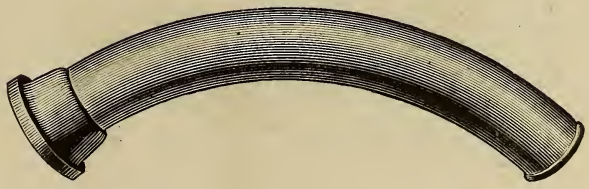
When necessary one or more of the outlets of the cross may be cast with spigot ends.



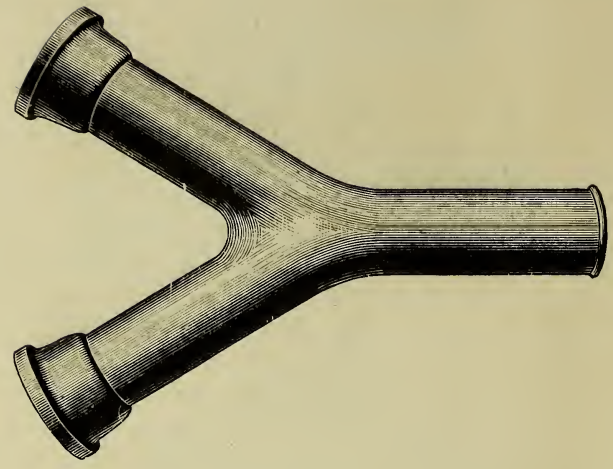
The elbow, or one-quarter bend, is to obtain a change of direction of 90 degrees.



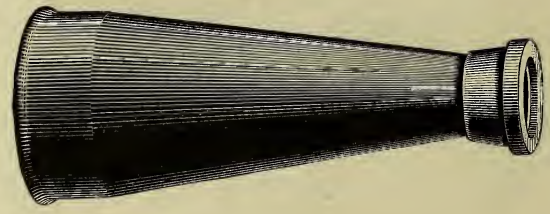
The one-eighth bend causes a change in direction of 45 degrees.



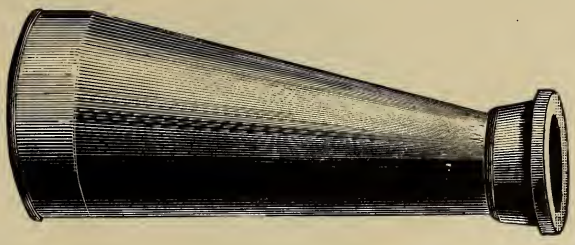
The easy bend is used to obtain a slighter change in direction, and is made in any angle required.



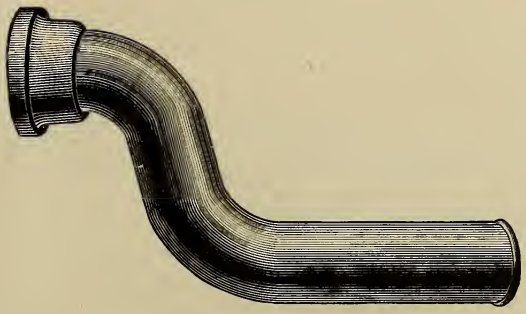
Y pipes are designed to cause a double change in direction, as at the forking of streets.



An ordinary reducer is used when it is desired to reduce the diameter of the main.

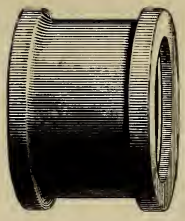


An angle reducer, as here shown, is used when desired to reduce the discharge of a main to smaller proportions without changing grade of trench; also by turning the reducer to any desired position, close parallel lines of pipe of different diameters may be connected. When placed in an inverted position from that here shown, the reducer acts in gas mains as a drip box on the smaller pipe—as the impurities drain from the smaller into the larger pipe.

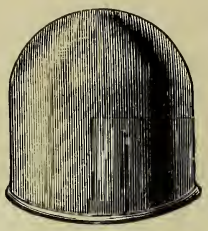


S pipes are manufactured to pass around obstacles, such as lines of pipes already laid.

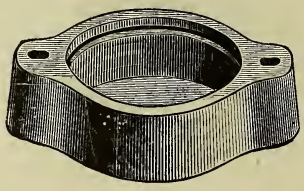
The parallel lines of pipe can be connected by this pipe.



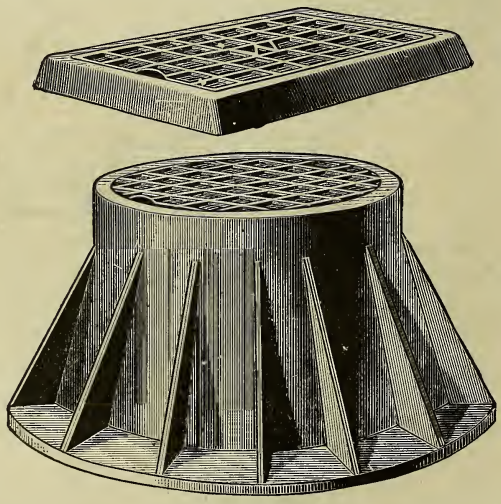
Sleeves connect the spigot ends of pipe.



Plugs are used to close the hub end of a line of pipe until it is desired to make further extensions. Plugs can also be used as strainers for suction pipe by perforating the crowns.

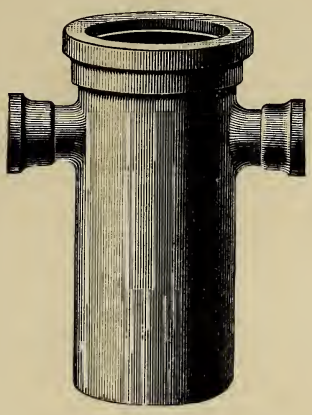


Spigot caps are of use to close the spigot end of the pipe. The cap may be bolted to the hub by means of a clamp, or to a band around the pipe.

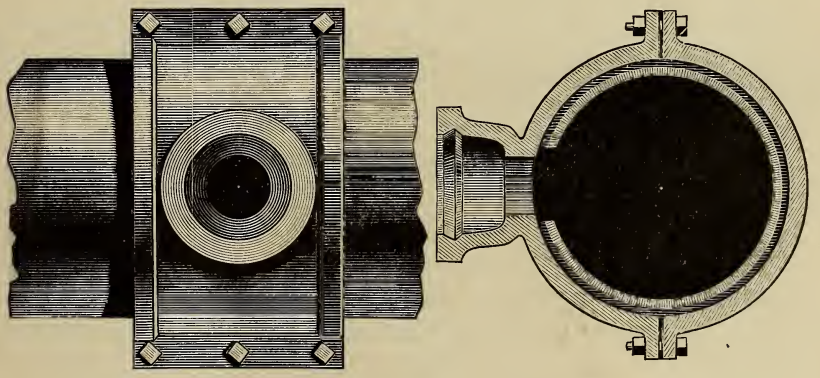


Valve boxes are used to protect valves and render them easy of access. We manufacture them in two styles as shown above.

We can also furnish fire cistern covers.



Drip-boxes are now in general use by gas works to drain water and other impurities from the pipe. The impurities accummulated in the drip-box should he removed at intervals.



The split tee which is here shown is of use when it is desired to tap a main without shutting off the water. It also obviates cutting the pipe in order to insert a branch

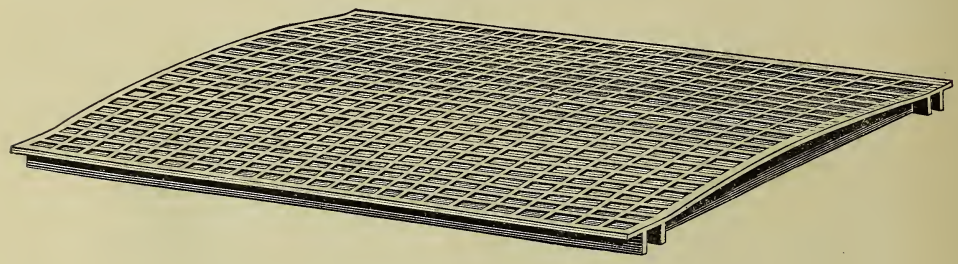
The manner of using is as follows: A circle the size of the orifice required is cut almost through the pipe: a split tee, having a branch the size of the circle, is then bolted around the main so that the opening

therein comes opposite to the circle. Rings of clay are then placed inside the branch and around the pipe at the ends of the sleeve. The space between the pipe and the sleeve is now filled with lead and caulked. Shrinkage is now taken up by tightening the bolts. A piece of pipe having a valve at one end is leaded into the branch. By means of a bar of iron passed through the valve, the circle already cut in the pipe, as above described, is broken through. The bar is then withdrawn and the valve closed.

When the water can be conveniently shut off in the main for a short time the valve on the smaller branch is unnecessary.

It is found that a sheet-lead gasket between the flanges prevents leakage at these points

We also manufacture split crosses of the same design and for the same purpose.

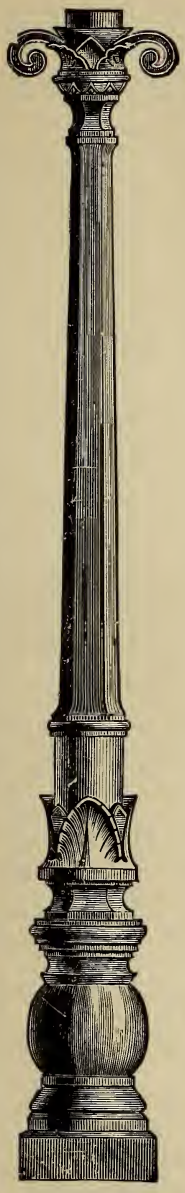


Gutter plates of the above design are in extensive use at crossings. The plate is arranged to give a sure footing.

We are also prepared to furnish all kinds of iron coverings for catch basins and sewers.

On the following page we show three styles of lamp-posts, weights and dimensions of which will be furnished upon application ; also posts of other patterns and sizes manufactured by us.

We refer you to page 88, where table of service of lamps may be found.



WEISBROOT. CIN. O.

WEIGHTS OF ORDINARY BRANCH CASTINGS.

2 x 2 x 2 x 2 Cross	40 lbs.
2 x 2 x 2 Tee	28 "
2 in. Elbow, 90°	14 "
2 in. Sleeve	10 "
2 in. Plug	2 "
2 in. one-eighth Bend, 45°	15 "
3 x 3 x 3 x 3 Cross	104 "
3 x 3 x 2 x 2 Cross	90 "
3 x 3 x 3 Tee	76 "
3 x 3 x 2 Tee	76 "
3 in. Elbow, 90°	34 "
3 in. one-eighth Bend	30 "
3 in. Sleeve	20 "
3 in. Plug	5 "
3 in. Cap	15 "
3 in. Branch Pipe, 45°	90 "
3 to 2 Reducer	35 "
4 x 4 x 4 x 4 Cross	150 "
4 x 4 x 3 x 3 Cross	114 "
4 x 4 x 2 x 2 Cross	110 "
4 x 4 x 4 Tee	100 "
4 x 4 x 3 Tee	90 "
4 x 4 x 2 Tee	87 "
4 in. Elbow, 90°	48 "
4 in. one-eighth Bend, 45°	65 "
4 in. Sleeve	44 "
4 in. Plug	8 "
4 in. Cap	25 "
4 in. S Pipe	90 "
4 in. Drip Box	235 "
4 to 3 Reducer	42 "
4 to 2 Reducer	40 "
6 x 6 x 6 x 6 Cross	200 "
6 x 6 x 4 x 4 Cross	150 "
6 x 6 x 3 x 3 Cross	160 "
6 x 6 x 6 Tee	150 "
6 x 6 x 4 Tee	130 "
6 x 6 x 3 Tee	125 "
6 x 6 x 2 Tee	120 lbs.
6 in. Elbow, 90°	110 "
6 in. one-eighth Bend 45°	85 "
6 in. Sleeve	65 "
6 in. Plug	12 "
6 in. Cap	60 "
6 in. S Pipe	190 "
6 x 6 x 4 Branch Pipe, 45°	145 "
6 to 4 Reducer	95 "
6 to 4 Angle Reducer for Gas	55 "
6 to 3 Reducer	80 "
6 to 3 Angle Reducer for Gas	45 "
8 x 8 x 8 x 8 Cross	325 "
8 x 8 x 6 x 6 Cross	265 "
8 x 8 x 4 x 4 Cross	266 "
8 x 8 x 3 x 3 Cross	225 "
8 x 8 x 8 Tee	266 "
8 x 8 x 6 Tee	252 "
8 x 8 x 4 Tee	222 "
8 x 8 x 3 Tee	220 "
8 in. Elbow, 90°	145 "
8 in. one-eighth Bend, 45°	160 "
8 in. one-sixteenth Bend, 22½°	155 "
8 in. Sleeve	86 "
8 in. Plug	26 "
8 in. Drip Box and Cover	355 "
8 to 6 Reducer	126 "
8 to 4 Reducer	116 "
8 to 3 Reducer	116 "
10 x 10 x 10 x 10 Cross	510 "
10 x 10 x 8 x 8 Cross	415 "
10 x 10 x 6 x 6 Cross	388 "
10 x 10 x 4 x 4 Cross	338 "
10 x 10 x 3 x 3 Cross	350 "
10 x 10 x 10 Tee	390 "
10 x 10 x 8 Tee	330 "
10 x 10 x 6 Tee	312 "
10 x 10 x 4 Tee	292 "

10 x 10 x 3 Tee	290 lbs.
10 in. Elbow, 45°	225 "
10 in. one-eighth Bend, 45°	190 "
10 in. one-sixteenth Bend, 22½°	165 "
10 in. Sleeve	140 "
10 in. Plug	46 "
10 in. Drip Box	760 "
10 to 8 Reducer	212 "
10 to 6 Reducer	150 "
10 to 4 Reducer	128 "
12 x 12 x 12 x 12 Cross	700 "
12 x 12 x 10 x 10 Cross	650 "
12 x 12 x 8 x 8 Cross	615 "
12 x 12 x 6 x 6 Cross	540 "
12 x 12 x 4 x 4 Cross	525 "
12 x 12 x 3 x 3 Cross	495 "
12 x 12 x 12 Tee	565 "
12 x 12 x 10 Tee	510 "
12 x 12 x 8 Tee	492 "
12 x 12 x 6 Tee	484 "
12 x 12 x 4 Tee	460 "
12 in. Elbow, 90°	370 "
12 in. one-eighth Bend, 45°	290 "
12 in. one-sixteenth Bend, 22½°	260 "
12 in. Sleeve	176 "
12 in. Plug	66 "
12 to 10 Reducer	278 "
12 to 8 Reducer	254 "
12 to 6 Reducer	230 "
12 to 4 Reducer	250 "
14 x 10 Cross	750 "
14 x 8 Cross	635 "
14 x 6 Cross	570 "
14 x 12 Tee	650 "
14 x 10 Tee	650 "
14 x 8 Tee	575 "
14 x 6 Tee	545 "
14 x 4 Tee	525 "
14 x 3 Tee	490 "
14 in. Elbow	450 "
14 in. Sleeve	208 "
14 in. Plug	70 "
14 to 12 Reducer	475 "
14 to 10 Reducer	430 "
14 to 8 Reducer	340 lbs.
14 to 6 Reducer	285 "
16 x 16 x 16 x 16 Cross	1,025 "
16 x 16 x 14 x 14 Cross	1,070 "
16 x 16 x 12 x 12 Cross	1,025 "
16 x 16 x 10 x 10 Cross	1,010 "
16 x 16 x 8 x 8 Cross	825 "
16 x 16 x 6 x 6 Cross	700 "
16 x 16 x 4 x 4 Cross	650 "
16 x 16 x 16 Tee	790 "
16 x 16 x 14 Tee	850 "
16 x 16 x 12 Tee	825 "
16 x 16 x 10 Tee	890 "
16 x 16 x 8 Tee	755 "
16 x 16 x 6 Tee	630 "
16 x 16 x 4 Tee	655 "
16 in. Elbow, 90°	525 "
16 in. one-eighth Bend, 45°	510 "
16 in. Sleeve	340 "
16 in. Plug	100 "
16 to 12 Reducer	475 "
16 to 10 Reducer	435 "
20 x 20 x 20 x 20 Cross	1,790 "
20 x 20 x 12 x 12 Cross	1,370 "
20 x 20 x 10 x 10 Cross	1,225 "
20 x 20 x 8 x 8 Cross	1,000 "
20 x 20 x 6 x 6 Cross	1,000 "
20 x 20 x 4 x 4 Cross	1,000 "
20 x 20 x 20 Tee	1,375 "
20 x 20 x 16 Tee	1,115 "
20 x 20 x 12 Tee	1,025 "
20 x 20 x 10 Tee	1,090 "
20 x 20 x 8 Tee	900 "
20 x 20 x 6 Tee	875 "
20 x 20 x 4 Tee	845 "
20 in. Elbow, 90°	900 "
20 in. one-eighth Bend, 45°	740 "
20 in. Sleeve	500 "
20 in. Plug	150 "
20 in. Cap	550 "
20 in. Drip Box and Cover	1,420 "
20 in. Y, 45°	1,655 "
20 to 16 in. Reducer	690 "
20 to 14 in. Reducer	575 "

20 to 12 in. Reducer	540 lbs.
20 to 8 in. Reducer	300 "
24 x 24 x 24 x 24 Cross	2,190 "
24 x 24 x 20 x 20 Cross	2,020 "
24 x 24 x 6 x 6 Cross	1,340 "
24 x 24 x 24 Tee	1,875 "
24 x 24 x 12 Tee	1,425 "
24 x 24 x 8 Tee	1,375 "
24 x 24 x 6 Tee	1,375 "
24 in. Elbow, 90°	1,400 "
24 in. one-eighth Bend, 45°	1,425 "
24 in. one-sixteenth Bend, 22½°	1,280 "
24 in. Sleeve	710 "
24 in. Plug	185 "
24 x 24 x 24 Branch Pipe, 45°	2,765 "
24 x 24 x 20 Branch Pipe, 45°	2,145 "
24 to 20 Reducer	745 "
30 x 30 x 20 x 20 Cross	2,635 "
30 x 30 x 12 x 12 Cross	2,250 "
30 x 30 x 8 x 8 Cross	1,995 "
30 x 30 x 30 Tee	3,025 lbs.
30 x 30 x 24 Tee	2,640 "
30 x 30 x 20 Tee	2,200 "
30 x 30 x 12 Tee	2,050 "
30 x 30 x 10 Tee	2,035 "
30 x 30 x 6 Tee	1,825 "
30 in. one-eighth Bend, 45°	2,000 "
30 in. one-sixteenth Bend, 22½°	1,735 "
30 in. Sleeve	965 "
30 in. Plug	370 "
30 x 30 x 30 Branch Pipe, 45°	4,170 "
30 to 24 Reducer	1,305 "
30 to 18 Reducer	1,585 "
36 x 36 x 36 Tee	5,140 "
36 x 36 x 30 Tee	4,200 "
36 x 36 x 12 Tee	4,050 "
36 in. Sleeve	1,500 "
36 x 36 x 36 Branch Pipe, 45°	10,300 "
36 to 30 Reducer	1,730 "

We are prepared to make all kinds of branch or connection castings in addition to those included in the above list.

TABLES SHOWING DISCHARGE IN GALLONS PER MINUTE FOR SINGLE ACTING PLUNGER PUMPS.—PER FOOT OF STROKE.

The tables of discharge for single acting and double acting pumps are calculated for diameters of 10 to 30 inches, and for speeds of 1 to 30 revolutions per minute, and represent the plunger or piston displacements per foot of stroke per revolution.

Thus, the table gives for a pump with 15-inch piston or plunger, at 12 revolutions per minute, a discharge of 110.16 gallons for single acting pump, and 220.32 gallons for double acting pump.

Now, if such a pump had a stroke of 36 inches, the discharge would be $3 \times 110.16 = 330.48$ gallons in the first case, and $3 \times 220.32 = 660.96$ gallons in the second case.

In estimating an actual delivery of water, a slip or loss of action of four per cent. should be allowed, which would make the true discharges in all cases 96-100 of the quantities given in the table.

There are many instances where the loss of action of new pumps in good condition is considerably less than four per cent., but the majority of pumps are doing clever work when delivering 96 per cent. of the calculated displacements.

DISCHARGE IN GALLONS PER MINUTE FOR SINGLE ACTING PLUNGER PUMPS. PER FOOT OF STROKE.

Diameter of Cylinder	REVOLUTIONS PER MINUTE.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10	4.080	8.160	12.240	16.320	20.400	24.480	28.560	32.640	36.720	40.800	44.880	48.960	53.040	57.120	61.200
10¼	4.286	8.572	12.858	17.144	21.430	25.716	30.002	34.288	38.574	42.860	47.146	51.432	55.718	60.004	64.290
10½	4.498	8.996	13.494	17.992	22.490	26.988	31.486	35.984	40.482	44.980	49.478	53.976	58.474	62.972	67.470
11	4.937	9.874	14.811	19.748	24.685	29.622	34.559	39.496	44.433	49.370	54.307	59.244	64.181	69.118	74.055
11¼	5.164	10.328	15.492	20.656	25.820	30.984	36.148	41.312	46.476	51.640	56.804	61.968	67.132	72.296	77.460
11½	5.396	10.792	16.188	21.584	26.980	32.376	37.772	43.168	48.564	53.960	59.356	64.752	70.148	75.544	80.940
12	5.875	11.750	17.625	23.500	29.375	35.250	41.125	47.000	52.875	58.750	64.625	70.500	76.375	82.250	88.125
12¼	6.122	12.244	18.366	24.488	30.610	36.732	42.854	48.976	55.098	61.220	67.342	73.464	79.586	85.708	91.830
12½	6.375	12.750	19.125	25.500	31.875	38.250	44.625	51.000	57.375	63.750	70.125	76.500	82.875	89.250	95.625
13	6.895	13.790	20.685	27.580	34.475	41.370	48.265	55.160	62.055	68.950	75.845	82.740	89.635	96.530	103.425
13½	7.436	14.872	22.308	29.744	37.180	44.616	52.052	59.488	66.924	74.360	81.796	89.232	96.668	104.104	111.540
14	7.997	15.994	23.991	31.988	39.985	47.982	55.979	63.976	71.973	79.970	87.967	95.964	103.961	111.958	119.955
14½	8.578	17.156	25.734	34.312	42.890	51.468	60.046	68.624	77.202	85.780	94.358	102.936	111.514	120.092	128.670
15	9.180	18.360	27.540	36.720	45.900	55.080	64.260	73.440	82.620	91.800	100.980	110.160	119.340	128.520	137.700
15½	9.802	19.604	29.406	39.208	49.010	58.812	68.614	78.416	88.218	98.020	107.822	117.624	127.426	137.228	147.030
16	10.445	20.890	31.335	41.780	52.225	62.670	73.115	83.560	94.005	104.450	114.895	125.340	135.785	146.230	156.675
16½	11.108	22.216	33.324	44.432	55.540	66.648	77.756	88.864	99.972	111.080	122.188	133.296	144.404	155.512	166.620
17	11.748	23.496	35.244	46.992	58.740	70.488	82.236	93.984	105.732	117.480	129.228	140.976	152.724	164.472	176.220
17½	12.495	24.990	37.485	49.980	62.475	74.970	87.465	99.960	112.455	124.950	137.445	149.940	162.435	174.930	187.425
18	13.219	26.438	39.657	52 876	66.095	79.314	92.533	105.752	118.971	132.190	145.399	158.628	171.847	185.066	198.285
18½	13.964	27.928	41.892	55.856	69.820	83.784	97.748	111.712	125.676	139.640	153.604	167.568	181.532	195.496	209.460
19	14.731	29.462	44.193	58.924	73.655	88.386	103.117	117.848	132.579	147.310	162.041	176.772	191.503	206.234	220.965

DISCHARGE IN GALLONS PER MINUTE FOR SINGLE ACTING PLUNGER PUMPS.

PER FOOT OF STROKE

Diameter of Cylinder.	REVOLUTIONS PER MINUTE.														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10	65.280	69.360	73.440	77.520	81.600	85.680	89.760	93.840	97.920	102.000	106.080	110.160	114.240	118.320	122.40
10¼	68.576	72.862	77.148	81.434	85.720	90.006	94.292	98.578	102.864	107.150	111.436	115.722	120.008	124.394	128.58
10½	71.978	76.476	80.964	85.462	89.960	94.458	98.956	103.454	107.952	112.450	116.948	121.446	125.944	130.442	134.94
11	78.992	83.929	88.866	93.803	98.740	103.677	108.614	113.551	118.488	123.425	128.362	133.299	138.236	143.173	148.11
11¼	82.624	87.788	92.952	98.116	103.280	108.444	113.608	118.772	123.936	129.100	134.264	139.428	144.592	149.756	154.92
11½	86.336	91.732	97.128	102.524	107.920	113.316	118.712	124.108	129.504	134.900	140.296	145.692	151.088	156.484	161.88
12	94.000	99.875	105.750	111.625	117.500	123.375	129.250	135.125	141.000	146.875	152.750	158.625	164.500	170.375	176.25
12¼	97.952	104.074	110.196	116.318	122.440	128.562	134.684	140.806	146.928	153.050	159.172	165.294	171.416	177.538	183.66
12½	102.000	108.375	114.750	121.125	127.500	133.875	140.250	146.625	153.000	159.375	165.750	172.125	178.500	184.875	191.25
13	110.320	117.215	124.110	131.005	137.900	144.795	151.690	158.585	165.480	172.375	179.270	186.165	193.060	199.955	206.85
13½	118.976	126.412	133.848	141.284	148.720	156.156	163.592	171.028	178.464	185.900	193.336	200.772	208.208	215.644	223.08
14	127.952	135.949	143.946	151.943	159.940	167.937	175.934	183.931	191.928	199.925	207.922	215.919	223.916	231.913	239.91
14½	137.248	145.826	154.404	162.982	171.560	180.138	188.716	197.294	205.872	214.450	223.028	231.606	240.184	248.762	257.34
15	146.880	156.060	165.240	174.420	183.600	192.780	201.960	211.140	220.320	229.500	238.680	247.860	257.040	266.220	275.40
15½	156.832	166.634	176.436	186.238	196.040	205.842	215.644	225.446	235.248	245.050	254.852	264.654	274.456	284.258	294.06
16	167.120	177.565	188.010	198.455	208.900	219.345	229.790	240.235	250.680	261.125	271.570	282.018	292.460	302.905	313.35
16½	177.728	188.836	199.944	211.052	222.160	233.268	244.376	255.484	266.592	277.700	288.808	299.916	311.024	322.132	333.24
17	187.968	199 716	211.464	223.212	234.960	246.708	258.456	270.204	281.952	293.600	305.448	317.196	328.944	340.692	352.44
17½	199.920	212.415	224.910	237.405	249.900	262.395	274.890	287.385	299.880	312.375	324.870	337.365	349.860	362.355	374.85
18	211.504	224.723	237.942	251.161	264.380	277.599	290.798	304.037	317.256	330.475	343.694	356.913	370.132	383.351	396.57
18½	223.424	237.388	251.352	265.316	279.280	293.244	307.208	321.172	335.136	349.100	363.064	377.028	390.992	404.956	418.92
19	235.696	250.427	265.158	279.889	294.620	309.351	324.082	338.813	353.544	368.275	383.006	397.737	412.468	427.199	441.93

DISCHARGE IN GALLONS PER MINUTE FOR SINGLE ACTING PLUNGER PUMPS. PER FOOT OF STROKE.

Diameter of Cylinder.	REVOLUTIONS PER MINUTE.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
19½	15.514	31.028	46.542	62.056	77.570	93.084	108.598	124.112	139.626	155.140	170.654	186.168	201.682	217.196	232.710
20	16.320	32.640	48.960	65.280	81.600	97.920	114.240	130.560	146.880	163.200	179.520	195.840	212.160	228.480	244.800
20½	17.146	34.292	51.438	68.584	85.730	102 876	120.022	137.168	154.314	171.460	188.606	205.752	222.898	240.044	257.190
21	17.993	35.986	53.979	71.972	89.965	107.958	125.951	143.944	161.937	179.930	197.923	215.916	233.909	251.902	269.895
21½	18.860	37.720	56.580	75.440	94.300	113.160	132.020	150.880	169.740	188.600	207.460	226.320	245.180	264.040	282.900
22	19.747	39.494	59.241	78.988	98.735	118.482	138.229	157.976	177.723	197.470	217.217	236.964	256.711	276.458	296.205
22½	20.655	41.310	61.965	82.620	103.275	123.930	144.585	165.240	185.895	206.550	227.205	247.860	268.515	289.170	309.825
23	21.583	43.166	64.749	86.332	107.915	129.498	151.081	172.664	194.247	215.830	237.413	258.996	280.579	302.162	323.745
23½	22.532	45.064	67.596	90.128	112.660	135.192	157.724	180.256	202.788	225.320	247.852	270.384	292.916	315.448	337.980
24	23.501	47.002	70.503	94.004	117.505	141.006	164.507	188.008	211.509	235.010	258.511	282.012	305.513	329.014	352.515
24½	24.490	48.980	73.470	97.960	122.450	146.940	171.430	195.920	220.410	244.900	269.390	293.880	318.370	342.860	367.350
25	25.500	51.000	76.500	102.000	127.500	153.000	178.500	204.000	229.500	255.000	280.500	306.000	331.500	357.000	382.500
25½	26.530	53.060	79.590	106.120	132.650	159.180	185.710	212.240	238.770	265.300	291.830	318.360	344.890	371.420	397.950
26	27.581	55.162	82.743	110.324	137.905	165.486	193.067	220.648	248.229	275.810	303.391	330.972	358.553	386.134	413.715
26½	28.565	57.130	85.695	114.260	142.825	171.390	199.955	228.520	257.085	285.650	314.215	342.780	371.345	399.910	428.475
27	29.743	59.486	89.229	118.972	148.715	178.458	208.201	237.944	267.687	297.430	327.173	356.916	386.659	416.402	446.145
27½	30.855	61.710	92.565	123.420	154.275	185.130	215.985	246.840	277.695	308.550	339.405	370.260	401.115	431.970	462.825
28	31.987	63.974	95.961	127.948	159.935	191.922	223.909	255.896	287.883	319.870	351.857	383.844	415.831	447.818	479.805
28½	33.140	66.280	99.420	132.560	165.700	198.840	231.980	265.120	298.260	331.400	364.540	397.680	430.820	463.960	497.100
29	34.313	68.626	102.939	137.252	171.565	205.878	240.191	274.504	308.817	343.130	377.443	411.756	446.069	480.382	514.695
29½	35.506	71.012	106.518	142.024	177.530	213.036	248.542	284.048	319.554	355.060	390.566	426.072	461.578	497.084	532.590
30	36.720	73.440	110.160	146.880	183.600	220.320	257.040	293.760	330.480	367,200	403.920	440.640	477.360	514.080	550.800

DISCHARGE IN GALLONS PER MINUTE FOR SINGLE ACTING PLUNGER PUMPS. PER FOOT OF STROKE.

Diam. of Cylinder.	REVOLUTIONS PER MINUTE.														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
19½	254.224	263.738	279.252	294.776	310.280	325.794	341.308	356.822	372.336	387.850	403.364	418.878	434.392	449.906	465.42
20	261.120	277.440	293.760	310.080	326.400	342.720	359.040	375.360	391.680	408.000	424.320	440.640	456.960	473.280	489.60
20½	274.336	291.482	308.628	325.774	342.920	360.066	377.212	394.358	411.504	428.650	445.796	462.942	480.088	497.234	514.38
21	287.888	305.881	323.874	341.867	359.860	377.853	395.846	413.839	431.832	449.825	467.818	485.811	503.804	521.797	539.79
21½	301.760	320.620	339.480	358.340	377.200	396.060	414.920	433.780	452.640	471 500	490.360	509.220	528.080	546.940	565.80
22	315.952	335.699	355.446	375.193	394.940	414.687	434.434	454.181	473.928	493.675	513.422	533.169	552.916	572.663	592.41
22½	330.480	351.135	371.790	392.445	413.100	433.755	454.410	475.065	495.720	516.375	537.030	557.685	578.340	598.995	619.65
23	345.328	366.911	388.494	410.077	431.660	453.243	474.826	496.409	517.992	539.575	561.158	582.741	604.324	625.907	647.49
23½	360.512	383.044	405.576	428.108	450.640	473.172	495.704	518.236	540.768	563.300	585.832	608.364	630.896	653.428	675.96
24	376.016	399.517	423.018	446.519	470.020	493.521	517.022	540.523	564.024	587.525	611.026	634.527	658.028	681.529	705.03
24½	391.840	416.330	440.820	465.310	489.800	514.290	538.780	563.270	587.760	612.250	636.740	661.230	685.720	710.210	734.70
25	408. 00	433.500	459.000	484.500	510.000	535.500	561.000	586.500	612.000	637.500	663.000	688.500	714.000	739.500	765.00
25½	424.480	451.010	477.540	504.070	530.600	557.130	583.660	610.190	636.720	663.250	689.780	716.310	742.840	769.370	795.90
26	441.296	468.877	496.458	524.039	551.620	579.201	606.782	634.363	661.944	689.525	717.106	744.687	772.268	799.849	827.43
26½	457.040	485.605	514.170	542.735	571.300	609.865	628.430	656.995	685.560	714.125	742.690	771.355	799.820	828.385	856.95
27	475.888	503.631	535.374	565.117	594.860	624.603	654.346	684.089	713.832	743.575	773.318	803.061	832.804	862.547	892.29
27½	493.680	524.535	555.390	586.245	617.100	647.955	678.810	709.665	740.520	771.375	802.230	833.085	863.940	894.795	925.65
28	511.792	543.779	575.766	607.753	639.740	671.727	703.714	735.701	767.688	799.675	831.662	863.649	895.636	927.623	959.61
28½	530.240	563.380	596.520	629.660	662.800	695.940	729.080	762.220	795.360	828.500	861.640	894.780	927.920	961.060	994.20
29	549.008	583.321	617.634	651.947	686.260	720.573	754.886	789.199	823.512	857.825	892.138	926.451	960.764	995.077	1029.39
29½	568.096	603.602	639.108	674.614	710.120	745.626	781.132	816.638	852.144	887.650	923.156	958.662	994.168	1029.690	1065.18
30	587.520	624.240	660.960	697.680	734.400	771.120	807.840	844.560	881.280	918.000	954.720	991.440	1028.160	1064.980	1101.69

TABLES SHOWING DISCHARGE IN GALLONS PER MINUTE FOR DOUBLE ACTING PLUNGER PUMPS.—PER FOOT OF STROKE.

Diameter of Cylinder.	REVOLUTIONS PER MINUTE.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10	8.160	16.320	24.480	32.640	40.800	48.960	57.120	65.280	73.440	81.600	89.760	97.920	106.080	114.240	122.40
10¼	8.572	17.144	25.716	34.228	43.860	51.432	60.004	68.576	77.148	85.720	94.292	102.864	111.436	120.008	128.58
10½	8.996	17.992	26.988	35.984	44.980	53.976	62.972	71.968	80.964	89.960	98.956	107.952	116.948	125.944	134.94
11	9.874	19.748	29.622	39.496	49.370	59.244	69.118	78.992	88.866	98.740	108.614	118.488	128.362	138.236	148.11
11¼	10.328	20.656	30.984	41.312	51.640	61.968	72.296	82.624	92.952	103.280	113.608	123.936	134.264	144.592	154.92
11½	10.792	21.584	32.376	43.168	53.960	64.752	75.554	86.336	97.128	107.920	118.712	129.504	140.296	151.088	161.88
12	11.750	23.500	35.250	47.000	58.750	70.500	82.250	94.000	105.750	117.500	129.250	141.000	152.750	164.500	176.25
12¼	12.244	24.488	36.732	48.976	61.220	73.464	85.708	97.952	110.196	122.440	134.684	146.928	159.172	171.416	183.66
12½	12.750	25.500	38.250	51.000	63.750	76.500	89.250	102.000	114.750	127.500	140.250	153.000	165.750	178 500	191.25
13	13.790	27.580	41.370	55.160	68.950	82.740	96.530	110.320	124.110	137.900	151.690	165.480	179.270	193.060	206.85
13½	14.872	29.744	44.616	59.488	74.360	89.232	104.104	118.976	133.848	148.720	163.592	178.464	193.336	208.208	223.08
14	15.994	31.988	47.982	63.916	79.970	95.964	111.958	127.952	143.946	159.940	175.934	191.928	207.922	223.916	239.91
14½	17.156	34.312	51.468	68.624	85.780	102.936	120.092	137.248	154.404	171.560	198.716	205.872	223.028	240.184	257.34
15	18.360	36.720	55.080	73.440	91.800	110.160	128.520	146.880	165.240	183.600	201.960	220.320	238.680	257.080	275.40
15½	19.604	39.208	58.812	78.416	98.020	117.160	137.228	156.832	176.436	196.040	215.644	235.248	254.852	274.456	294.06
16	20.890	41.780	62.670	83.560	104.450	125.340	146.230	167.120	188.010	208.900	229.790	250.680	271.570	292.460	313.35
16½	22.216	44.432	66.648	88.864	111.080	133.296	155.512	177.728	199.944	222.160	244.376	266.592	288.808	311.024	333.24
17	23.496	46.992	70.488	93.984	117.480	140.976	164.472	187.968	211.464	234.960	258.456	281.952	305.448	328.044	352.44
17½	24.990	49.980	74.970	99.960	124.950	149.940	174.930	199.920	224.910	249.900	274.890	299.880	324.870	349.860	374.85
18	26.438	52.876	79.314	105.752	132.190	158.628	185.066	211.504	237.942	264.380	290.798	317.256	343.694	370.132	396.57
18½	27.928	55.856	83.784	111.712	139.640	167.568	195.496	223.424	251.352	279.280	307.208	335.136	363.064	390.992	418.98
19	29.462	58.924	88.386	117.848	147.310	176.772	206.234	235.696	265.158	294.620	324.082	353.544	383.006	412.468	441.93

DISCHARGE IN GALLONS PER MINUTE FOR DOUBLE ACTING PLUNGER PUMPS. PER FOOT OF STROKE.

Diameter of Cylinder.	REVOLUTIONS PER MINUTE.														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10	130.560	138.720	146.880	155.040	163.200	171.360	179.520	187.680	195.840	204.000	212.160	220.320	228.480	236.640	244.800
10¼	137.152	145.724	154.296	162.868	171.440	180.012	188.584	197.156	205.728	214.300	222.872	231.444	240.016	248.788	257.160
10½	143.956	152.952	161.928	170.924	179.920	188.916	197.912	206.908	215.904	224.910	233.996	242.892	251.888	260.884	269.880
11	157.984	167.858	177.732	187.606	197.480	207.354	217.228	227.102	236.976	246.850	256.724	266.598	276.472	286.346	296.220
11¼	165.248	175.576	185.904	196.232	206.560	216.888	227.216	237.544	247.872	258.200	268.528	278.856	289.184	299.512	309.840
11½	172.672	183.464	194.256	205.048	215.840	226.320	237.424	248.216	259.008	269.800	280.592	291.384	302.176	312.968	323.760
12	188.000	199.750	211.500	223.250	235.000	246.750	258.500	270.250	282.000	293.750	305.500	317.250	329.000	340.750	352.500
12¼	195.904	208.148	220.392	232.636	244.880	257.124	269.368	281.612	293.856	306.100	318.344	330.588	342.832	355.076	367.320
12½	204.000	216.750	229.500	242.250	255.000	267.750	280.500	293.250	306.000	318.750	331.500	344.250	357.000	369.750	382.500
13	220.640	234.430	248.220	262.010	275.800	289.590	303.380	317.160	330.960	344.750	358.540	372.330	386.120	399.910	413.700
13½	237.952	252.824	267.696	282.568	297.440	312.312	327.184	342.056	356.928	371.800	386.672	401.544	416.416	431.288	446.160
14	255.904	271.898	287.892	303.886	319.880	335.874	351.868	367.862	383.856	399.850	415.844	431.838	447.832	463.826	479.820
14½	274.496	290.652	308.808	325.964	343.120	360.276	377.432	394.588	411.744	428.900	446.056	463.212	480.368	497.524	514.680
15	293.760	312.120	330.480	348.840	367.200	385.560	403.920	422.280	440.640	459.000	477.360	495.720	514.080	532.440	550.800
15½	313.664	333.268	352.872	372.476	392.080	411.684	431.288	450.892	470.496	490.100	509.704	529.308	548.912	568.516	588.120
16	334.240	355.130	376.020	396.910	417.800	438.690	459.580	480.470	501.360	522.250	543.140	564.036	584.920	605.810	626.700
16½	355.456	377.672	399.888	422.104	444.320	466.536	488.752	510.968	533.184	555.400	577.616	599.832	622.048	644.264	666.480
17	375.936	399.432	422.928	446.424	469.920	493.416	516.912	540.408	563.904	587.200	610.896	634.392	657.888	681.384	704.880
17½	399.840	424.830	449.820	474.810	499.800	524.790	549.780	574.770	599.760	624.750	649.740	674.730	699.720	724.710	749.700
18	423.008	449.446	475.884	502.322	528.760	555.198	581.596	608.074	634.512	660.950	687.388	713.826	740.264	786.702	793.140
18½	446.848	474.776	502.704	530.632	558.560	586.488	614.416	642.344	670.272	698.200	726.128	754.056	781.984	809.912	837.840
19	471.392	500.854	530.316	559.778	589.240	618.702	648.164	677.626	707.088	736.550	766.012	795.474	824.936	854.398	883.860

DISCHARGE IN GALLONS PER MINUTE FOR DOUBLE ACTING PLUNGER PUMPS. PER FOOT OF STROKE.

Diameter of Cylinder.	REVOLUTIONS PER MINUTE.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
19½	31.028	62.056	93.084	124.112	155.140	186.168	217.196	248.224	279.252	310.280	341.308	372.336	403.364	434.392	465.42
20	32.640	65.280	97.920	130.560	163.200	195.840	228.480	261.120	293.760	326.400	359.040	391.680	424.320	456.960	489.60
20½	34.292	68.584	102.876	137.168	171.460	205.752	240.044	274.336	308.628	342.920	377.212	411.504	445.796	480.088	514.38
21	35.986	71.972	107.958	143.944	179.930	215.916	251.902	287.888	323.874	359.860	395.846	431.832	467.818	503.804	539.79
21½	37.720	75.440	113.160	150.880	188.600	226.320	264.040	301.760	339.480	377.200	414.920	452.640	490.360	528.080	565.80
22	39.494	78.988	118.482	157.976	197.470	236.964	276.458	315.952	355.446	394.940	434.434	473.928	513.422	552.916	592.41
22½	41.310	82.620	123.930	165.240	206.550	247.860	289.170	330.480	371.790	413.100	454.510	495.720	537.030	578.340	619.65
23	43.166	86.332	129.498	172.664	215.830	258.996	302.162	345.328	388.494	431.660	474.826	517.992	560.158	604.324	647.49
23½	45.064	90.128	135.192	180.256	225.320	270.384	315.448	360.512	405.576	450.640	495.704	540.768	585.832	630.896	675.96
24	47.002	94.004	141.006	188.008	235.010	282.012	329.014	376.016	423.018	470.020	517.022	564.024	611.026	658.028	705.03
24½	48.980	97.960	146.940	195.920	244.900	293.880	342.860	391.840	440.820	489.800	538.780	587.760	636.740	685.720	734.70
25	51.000	102.000	153.000	204.000	255.000	306.000	357.000	408.000	459.000	510.000	561.000	612.000	663.000	714.000	765.00
25½	53.060	106.120	159.180	212.240	265.300	318.360	371.420	424.480	477.540	530.600	583.660	636.720	689.780	742.840	795.90
26	55.162	110.324	165.486	220.648	275.810	330.972	386.134	441.296	496.458	551.620	606.772	661.944	717.106	772.268	827.43
26½	57.130	114.260	171.390	228.520	285.650	342.780	399.910	457.040	514.170	571.300	628.430	685.560	742.690	799.820	856.95
27	59.486	118.972	178.458	237.944	297.430	356.916	416.402	475.888	535.374	594.860	654.346	713.832	773.318	832.804	892.29
27½	61.710	123.420	185.130	246.840	308.550	370.260	431.970	493.680	555.390	617.100	678.810	740.520	802.230	863.940	925.65
28	63.974	127.948	191.922	255.896	319.870	383.844	447.818	511.792	575.766	639.740	703.714	767.688	831.662	895.636	959.61
28½	66.280	132.560	198.840	265.120	331.400	397.680	463.960	530.240	596.530	662.800	729.080	795.360	861.640	927.920	994.20
29	68.626	137.252	205.878	274.504	343.130	411.756	480.382	549.008	617.634	686.260	754.886	823.512	892.138	960.766	1029.39
29½	71.012	142.024	213.036	284.048	355.060	426.072	497.084	568.096	639.108	710.120	780.132	853.144	923.156	994.168	1065.18
30	73.440	146.880	220.320	293.760	367.200	440.640	514.080	587.520	660.960	734.400	807.840	881.280	954.720	1028.160	1101.60

DISCHARGE IN GALLONS PER MINUTE FOR DOUBLE ACTING PLUNGER PUMPS. PER FOOT OF STROKE.

Diam. of Cylinder.	REVOLUTIONS PER MINUTE.														
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
19½	568.448	527.476	558.504	589.552	620.560	651.588	282.616	713.644	744.672	775.700	806.728	837.756	868.784	899.812	930.84
20	522.240	554.880	587.520	620.160	652.800	685.440	718.080	750.720	783.360	816.000	848.640	881.280	913.920	946.560	979.20
20½	548.672	582.964	617.256	651.548	685.840	720.132	754.424	788.716	823.008	857.300	891.592	925.884	960.176	994.468	1028.76
21	575.776	611.762	647.748	683.734	719.720	755.706	791.692	827.678	863.664	899.650	935.636	971.622	1007.608	1043.594	1079.58
21½	603.320	641.240	678.960	716.680	754.400	792.120	829.840	867.560	905.280	943.000	980.720	1018.440	1056.160	1093.880	1131.60
22	631.904	671.398	710.892	750.386	789.880	829.374	868.868	908.362	947.856	987.350	1026.844	1066.338	1105.832	1145.326	1184.82
22½	660.960	702.270	743.580	784.890	826.200	867.510	908.820	950.130	991.440	1032.750	1074.060	1115.370	1156.680	1197.990	1239.30
23	690.656	733.822	776.988	820.154	863.320	906.486	949.652	992.818	1035.984	1079.150	1122.316	1165.482	1208.648	1251.814	1294.98
23½	721.024	766.088	811.152	856.216	901.280	946.341	991.408	1036.472	1081.536	1126.600	1171.664	1216.728	1261.792	1306.856	1351.92
24	752.032	799.034	846.036	893.038	940.040	987.042	1034.044	1081.046	1128.048	1175.050	1222.052	1269.054	1316.056	1363.058	1410.06
24½	783.680	832.660	881.640	930.620	979.600	1028.580	1077.560	1126.540	1175.520	1224.500	1273.480	1322.460	1371.440	1420.420	1469.41
25	816.000	867.000	918.000	969.000	1020.000	1071.000	1122.000	1173.000	1224.000	1275.000	1326.000	1377.000	1428.000	1479.000	1530.00
25½	848.960	902.020	955.080	1008.140	1061.200	1114.260	1167.320	1220.380	1273.440	1327.500	1379.560	1432.620	1485.680	1538.740	1591.80
26	882.592	937.754	992.916	1048.078	1103.240	1158.402	1213.564	1268.726	1323.888	1379.050	1434.212	1489.374	1544.536	1599.798	1654.86
26½	914.080	971.210	1028.340	1085.470	1142.600	1219.730	1256.860	1313.990	1371.120	1428.250	1485.380	1542.710	1599.640	1656.770	1713.90
27	951.776	1011.262	1070.748	1130.234	1189.720	1249.206	1308.692	1368.178	1427.664	1487.150	1546.636	1606.122	1665.608	1725.094	1784.58
27½	987.360	1049.070	1110.780	1172.490	1234.200	1295.910	1357.620	1419.330	1481.040	1542.750	1604.460	1666.170	1727.880	1789.590	1851.30
28	1023.584	1087.558	1151.532	1215.506	1279.480	1343.454	1407.428	1471.402	1535.376	1599.350	1663.324	1727.298	1791.272	1855.246	1919.22
28½	1060.480	1126.760	1193.040	1259.320	1325.600	1391.880	1458.160	1524.440	1590.720	1657.000	1723.280	1789.560	1855.840	1922.120	1988.40
29	1098.016	1166.642	1235.268	1303.894	1372.520	1441.146	1509.772	1578.398	1647.024	1715.650	1784.276	1852.902	1921.528	1990.154	2058.78
29½	1136.192	1207.204	1278.216	1349.228	1420.240	1491.252	1562.264	1633.276	1704.288	1775.300	1846.312	1917.324	1988.336	2059.380	2130.36
30	1175.040	1248.480	1321.920	1395.360	1468.800	1542.240	1615.680	1689.120	1762.560	1836.000	1909.440	1982.880	2056.320	2129.980	2203.20

ALTITUDE OF JETS IN FEET.

Head on Jet in Pounds.	Head on Jet in Feet.	DIAMETER OF JET IN INCHES.									
		¼	⅜	½	⅝	¾	1	1⅛	1¼	1⅜	1½
20	46.16	32.843	37.282	39.502	40.833	41.721	42.831	43.201	43.497	43.739	43.941
25	57.70	36.892	43.828	47.296	49.377	50.764	52.498	53.076	53.800	53.917	54.232
30	69.24	39.276	49.264	54.258	57.255	59.252	61.749	62.581	63.247	63.792	64.246
40	92.32	. . . .	56.808	65.685	71.013	74.564	79.003	80.483	81.666	82.635	83.442
50	115.40	. . . .	59.912	73.784	82.107	87.656	94.592	96.904	98.754	99.267	101.528
60	138.48	. . . .	. . . .	78.553	90.538	98.529	108.516	111.846	114.509	116.688	118.504
70	161.56	. . . .	. . . .	79.992	96.306	107.182	120.776	125.308	128.933	131.899	134.371
80	184.64	. . . .	. . . .	. . . .	99.410	113.615	131.371	137.290	142.025	145.899	149.128
90	207.72	. . . .	. . . .	. . . .	99.851	117.829	140.302	147.793	153.786	158.689	162.775
100	230.80	. . .	. . .	. . . .	. . . .	119.824	147.568	156.816	164.214	170.268	175.312
110	253.88	. . .	. .	. . . .	. . . .	. . . .	153.169	164.359	173.311	180.636	186.739
120	276.96	. . . .	. . . .	. . . .	. .	. . . .	157.106	170.423	181.077	189.793	197.057
130	300.04	. . . .	. . .	. . . .	. . . .	. . . .	159.378	175.007	187.510	197 740	206.265
140	323.12	. . . .	. . . .	. . . .	. . . .	. . . .	159.985	178.111	192.612	204.476	214.363
150	346.20	. . . .	. . . .	. . . .	. . . .	.	.	179.736	196.382	210.002	221.352
160	369.28	. . . .	. . . .	. .	. . . .	. . .	. . . .	179.880	198.820	214.317	227.230
170	392.36	. . . .	. . . .	. . .	. . . .	. . . .	. . . .	. . . .	199.940	217.421	231.999
180	415.44	. .	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .	219.315	235.658

The altitude of jets has been calculated from the formula—

$$H' = H - \left(\frac{H^2 \times .0125}{8 \times d}\right)$$

When H = head on jet in feet,
d = diameter of nozzle in inches,
H′ = altitude of jet.

With a pressure of 60 pounds on a 1.125-inch nozzle, the altitude of jet will be—

$$60 \times 2.308 = 138.48 \text{ feet head on jet.}$$

And

$$138.48 - \frac{138.48^2 \times 0.0125}{1.125 \times 8} = 111.846 \text{ feet.}$$

but with a pressure of 120 pounds, the height of jet will be—

$$276.96 - \frac{276.96^2 \times 0.0125}{1.125 \times 8} = 170.423 \text{ feet.}$$

DISCHARGE OF JETS IN GALLONS PER MINUTE.

Head on Jet in Pounds.	Head on Jet in Feet.	DIAMETER OF JET IN INCHES.									
		¼	⅜	½	⅝	¾	1	1⅛	1¼	1⅜	1½
20	46.16	7.827	17.610	31.307	48.917	70.440	125.227	158.490	195.667	236.757	281.761
25	57.70	8.751	19.689	35.002	54.691	78.755	140.009	177.199	218.765	264.705	315.021
30	69.24	9.586	21.568	38 343	59.911	86.272	153.373	194.112	239.645	289.970	345.088
40	92.32	. . . .	24.904	44.274	69.178	99.616	177.095	224.135	276.710	334.819	398.462
50	115.40	. . . .	27.843	49.490	77.328	111.352	197.959	250.543	309.312	374.267	445.409
60	138.48	. . . .	. . . .	54.190	84.672	121.927	216.760	274.337	338.688	409.812	487.710
70	161.56	. . . .	. . . .	58.568	91.512	131.777	234.270	296.499	366.048	442.918	527.109
80	184.64	. . . .	. .	. . . .	97.776	140.797	250 306	316.794	391.104	473.236	563.190
90	207.72	. .	. . . .	. . .	103.752	149.403	265.605	336.156	415.008	502.160	597.611
100	230.80	. . . .	. . . .	. . . .	. . . .	157.490	279.982	354.352	437.472	529.341	629.960
110	253.88	. . .	. . . .	. . . .	. . .	. . . .	293.622	371.615	458.784	555.129	660.649
120	276.96	. . . .	. . . .	. . . .	. . . .	. . . .	306.708	388.178	479.232	579.871	690.094
130	300.04	. .	. . . .	. . . .	. . . .	. .	319.242	404.040	498.816	603.567	718.295
140	323.12	. . . .	. . . .	. . .	. . . .	. . . .	331.223	419.204	517.536	626.218	745.252
150	346.20	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	434.134	535.968	648.521	771.794
160	369.28	. . . .	. . . .	. .	. .	. . . .	. .	448.271	553.421	669.639	796.925
170	392.36	. . . .	. . . .	. . . .		. . .	. . . .	. . . .	570.470	690.269	822.577
180	415.44	. . . .	. .	. . . .	. . . .	. .	. . . .	. . . .	. . . .	710.272	845.282

The above table has been calculated by the formula—

$$G = \sqrt{H} \times (8\ d)^2 \times 0.288$$

When G = discharge in gallons per minute,
H = head on jet in feet,
d = diameter of nozzle in inches.

The above nozzle under 60 and 120 pounds pressure, and 1.125-inch orifice, would discharge

$\sqrt{138.48} \times (8 \times 1.125)^2 \times 0.288 = 274.337$ gallons for 60 pounds pressure, and
$\sqrt{276.96} \times (8 \times 1.125)^2 \times 0.288 = 388.224$ gallons for 120 pounds pressure.

TABLE OF CONTENTS IN CUBIC FEET AND U. S. GALLONS, AND WEIGHT OF WATER (AT 62½ POUNDS PER CUBIC FOOT) CONTAINED IN ONE FOOT LENGTHS OF DIFFERENT INTERNAL DIAMETERS OF PIPE, AND SQUARE ROOT OF DIAMETER IN FEET.

Diam. in Inches.	Diam. in feet.	U. S. Gals. of 231 Cub. Inches.	Weight of Water, lbs.	Square Root of Diameter in Feet.	Diam. in Inches.	Diam. in feet.	U. S. Gals. of 231 Cub. Inches.	Weight of Water in lbs.	Square Root of Diam. in Feet.
1	.0833	.0408	.3395	.289	25	2.083	25.50	212.20	1.443
2	.1667	.1632	1.358	.408	26	2.167	27.58	229.51	1.472
3	.2500	.3672	3.055	.500	27	2.250	29.74	247.51	1.500
4	.3333	.6528	5.432	.579	28	2.333	31.99	266.18	1.528
5	.4167	1.020	8.488	.645	29	2.417	34.31	285.53	1.555
6	.5000	1.469	12.223	.707	30	2.500	36.72	305.57	1.581
7	.5833	1.999	16.636	.764	31	2.583	39.21	326.27	1.607
8	.6667	2.611	21.729	.817	32	2.667	41.78	347.66	1.633
9	.7500	3.305	27.501	.866	33	2.750	44.43	369.74	1.658
10	.8333	4.080	33.952	.913	34	2.833	47.16	392.48	1.683
11	.9167	4 937	41.082	.957	35	2.917	49.98	415.90	1,708
12	1.	5 875	48.891	1.000	36	3.	52.88	440.00	1.732
13	1.083	6.895	57.379	1.041	37	3.083	55.86	464.80	1.756
14	1.167	7.997	66 545	1.080	38	3.167	58.92	490.24	1.779
15	1.250	9.180	76.392	1.118	39	3.250	62.06	516.40	1.803
16	1.333	10.44	86.916	1.155	40	3.333	65.28	543.24	1.825
17	1.417	11.79	98.121	1.190	41	3.417	68.58	570.72	1.849
18	1.500	13.22	110.	1.224	42	3.500	71.97	598.92	1.871
19	1.583	14.73	122.56	1.258	43	3.583	75.44	627.81	1.894
20	1.667	16.32	135.81	1.291	44	3.667	78.99	657.32	1.915
21	1.750	17.99	149.73	1.323	45	3.750	82.62	687.56	1 937
22	1.833	19.75	164.33	1.354	46	3.833	86.33	718.40	1.958
23	1.917	21.58	179.60	1.384	47	3.917	90.13	750.06	1.979
24	2.	23.50	195.56	1.414	48	4.	94.00	782.24	2.000

For larger diameters than those given, take one-half the size required from the table, and multiply by 4 so also with gallons and weights.

CAPACITY OF CISTERNS OF DIFFERENT DIAMETERS AND DIFFERENT DEPTHS IN UNITED STATES GALLONS, 231 CUBIC INCHES.

Diameter Feet.	Depth Feet.	U. S Galls. 231 Inches.	Cubic Feet.	Diameter Feet.	Depth Feet.	U. S. Galls. 231 Inches.	Cubic Feet.
12	8	6769	905	24	12	40607	5429
14	9	10359	1385	26	13	51628	6902
16	9	13535	1810	28	14	64481	8621
18	10	19034	2545	30	15	79310	10603
20	10	23499	3142	32	16	96253	12868
22	11	31277	4181	34	17	115451	15435

GAS LIGHT.

In 1659 Mr. Thomas Shirley communicated some experiments on the gas issuing from a well near Wigan, England. Nearly 100 years later, a Mr. Spedding proposed to light the streets of the town of Whitehaven with the above gas, demonstrating its practicability by using it to light his own office, but his proposal was refused; and it was not until the year 1792 that Mr. Wm. Murdoch, engineer to Messrs. Bolton & Watt, practically employed coal gas for the purpose of artificial illumination, by lighting his own house and office with it at Redneth, Cornwall. To him belongs the credit of first practically demonstrating the feasibility of making and distributing this illuminating agency. A few years after this, in the Spring of 1802, upon the occasion of the national illumination in honor of the peace of Amiens, he lighted up part of the Soho manufactory with a public display of gas lights.

The earliest application of this artificial light on a large systematic scale was made in Manchester, where an apparatus for lighting the great cotton mills of Phillipps & Lee was fitted up in 1804, under the direction of Mr. Murdoch.

In 1802 coal gas was first used in Paris, although the city was not lighted with it until 1820.

The first incorporated gas company in London was "The London and Westminster Gas Light and Coke Company," with a capital of £200,000, in 1810.

The first practical application of gas light in the United States was in the bath house and contiguous apartments at Newport, R. I., which were lighted by David Melville in 1813.

The eminent gas engineer, Samuel Clegg, to whose inventive genius in the perfecting of apparatus for manufacturing gas we owe so much, was in this same year retained as engineer by "The Chartered Gas Light and Coke Company" of London. He was born in Manchester, March 2, 1781. Among many inventions and adaptations to his credit in the making of coal gas are the following: In 1805 he first used lime in its purification. In 1806 he communicated to the Society of Arts the first plan of an apparatus for

lighting manufactories. In 1809 he lighted the factory of Mr. Harris at Coventry. Here he introduced a paddle at the bottom of the tank to agitate the lime. In 1811 he introduced the wet lime purifier as a separate vessel, the first ever employed for that purpose. In this same year he first used the hydraulic main. In 1812, at the cotton mills at Hyde, he first attached to the gas-holder the mechanism for regulating its specific gravity. In 1815 he invented the gas meter. In 1816 he invented and patented the gas governor. In 1817 he invented the collapsing gas holder. In 1841 the first edition of "Clegg on Coal Gas" was published; in 1853 the second; in 1859 the third; and in 1866 the fourth. This distinguished gentleman died in 1861 in his eightieth year.

After the first attempt to illuminate with coal gas in Newport, R. I., no very rapid advance was made, and it was not until 1834 that New York was so lighted. Philadelphia followed in 1835, Chicago in 1840, and Cincinnati in 1841.

GENERATION OF ILLUMINATING GASES.

When coals are heated in a retort to ignition, the progress of decomposition is as follows: First, and before the retort becomes red hot, steam issues along with the atmospheric air. When the retort begins to redden, tar distils in considerable quantity, with some combustible gas, of which hydrogen mixed with ammoniacal gas forms a part. The evolution of gas increases as the retort becomes hotter, with a continual production of tar and ammoniacal liquor, as well as sulphurous acid, from the pyrites of coal, which unites with the ammonia. When the retort has come to a white heat, the disengagement of gas is most active. By and by the gaseous production diminishes, and eventually ceases entirely, although the heat be increased. In the retort a quantity of carbonized coal, or *coke*, remains, while tar forms at the bottom of the receiver, covered with the ammoniacal liquor, and combined with carbonic and sulphurous acids and sulphuretted hydrogen.

If, during this distillation, the combustible gas be collected and examined at the several stages of the process, it is found to differ extremely in its luminiferous powers. That which comes off before the retort has acquired its proper temperature gives a feeble light, and resembles the gas obtained by the ignition of moist charcoal, consisting chiefly of hydrogen.

That evolved when the retort has just acquired throughout a vivid white heat is the best of all, consisting chiefly of bicarbonated hydrogen, with a specific gravity of, say 0.650. At a later period, as after say 5 hours, the gas evolved will have a specific gravity of .5. Toward the end of the operation, say in 10 hours, it will have a specific gravity of .345. The larger and best proportion of the gas is disengaged during the first hour, amounting to about one-fifth of the whole. In the three following hours the disengagement is tolerably uniform, constituting in all .54 in the sixth hour it is .1; in the seventh and eighth hours .16.

From these observations are derived the rules for the production of a good light—gas from coal. They show that the distillation should commence with a retort previously heated to a white heat, since thereby good gas is immediately produced; that this heat should be steadily continued during the whole operation, and that it should not be increased, especially toward the end, for fear of generating carbonic oxide and hydrogen gases. Upon an average a pound of good coal affords four cubic feet of gas.

Below we give the table of temperatures, expressed in colors.

Faint red	960°	Fahr.
Dull red	1290°	"
Brilliant red	1470°	"
Cherry red	1650°	"
Bright cherry red	1830°	"
Dull orange	2010°	"
Bright orange	2190°	"
White heat	2370°	"
Bright white	2550°	"
Brilliant white	2730°	"

Coal gas, as it issues from the retort, can not be directly employed for illumination. It contains vapors of tar and oil, also steam impregnated with the carbonate, sulphite, and hydro-sulphuret of ammonia, which would readily condense and prove obstructions in the pipes through which the gas must be distributed. Crude coal gas contains, besides those enumerated, sulphuretted hydrogen, carbonic acid, and carbonic oxide gases; the former exhales, during combustion for light, an offensive sulphurous odor, while the latter enfeeble the illuminating power of the gas, and should be removed.

In such a book as this we can not give a detailed account of the apparatus used for making and purifying gas, but we append a few tests, which can be applied by any one to discover impurities in gas.

IMPURITIES IN GAS.

To ascertain the presence of

Carbonic acid.—Impregnate water with the gas, and add a few drops of sulphuric acid, when minute bubbles of carbonic acid gas will be rapidly disengaged.

Sulphuretted hydrogen.—Take a solution of nitrate of silver and distilled water. Saturate a piece of writing paper in it, and hold over a jet of unlighted gas. Pure gas will produce no discoloration. If a brown stain is given, the lime in the purifiers requires renewing. Sulphuretted hydrogen prevails more extensively if there be much pyritous matter in the coal.

Ammonia —Take litmus paper reddened by acid and apply to a gas jet as above. If the blue color of the litmus returns, the gas contains ammonia.

USEFUL PRODUCTS OF COAL GAS MANUFACTURE.

Tar yields benzole of great solvent powers, adapted for preparing varnishes, for making oil of bitter almonds, for removing grease spots, and for cleansing soiled white gloves. It also gives naphtha an important solvent of india rubber and gutta percha. It also forms lampblack, the principal ingredient in printer's ink; is largely used in asphalt for pavements; mixed with red hot clay, it is a powerful disinfectant; with waste coal dust and pressed, it is an excellent and compact artificial fuel.

The water condensed with the tar contains much ammonia, readily convertible into sulphate of ammonia.

Cyanides are also present, and these are readily convertible into Prussian blue.

Naphthaline may be made into beautiful red coloring matter, closely resembling that obtained from madder.—*Dr. Lyon Playfair.*

TABLE, SHOWING THE DISCHARGES OF GAS IN CUBIC FEET PER HOUR, THROUGH PIPES OF DIFFERENT DIAMETERS AND VARIOUS LENGTHS IN YARDS LINEAL.

Pressure of Water, in Inches. 1, 1.5, 2, 2.5. Specific Gravity, .400.

LENGTH IN YARDS.	2 INCHES DIAMETER.				LENGTH IN YARDS.	3 INCHES DIAMETER.			
	1	1.5	2	2.5		1	1.5	2	2.5
100	1208	1480	1708	1908	100	3100	4075	4700	5260
150	986	1208	1394	1560	150	2718	3329	3840	4293
200	853	1046	1208	1350	200	2350	2881	3328	3718
300	697	853	984	1103	300	1920	2353	2714	3037
500	540	661	762	853	500	1488	1823	2108	2353
750	441	540	624	697	750	1216	1488	1718	1920
1000	381	468	540	534	1000	1054	1289	1488	1644
1250	342	419	484	540	1250	942	1155	1332	1354
1500	312	381	442	493	1500	859	1052	1216	1357
1750	280	353	408	457	1750	795	974	1130	1279
2000	270	331	381	427	2000	744	912	1054	1176

LENGTH IN YARDS.	4 INCHES DIAMETER.				LENGTH IN YARDS.	6 INCHES DIAMETER.			
	1	1.5	2	2.5		1	1.5	2	2.5
100	6831	8370	9658	10800	100	18820	23050	26600	29770
150	5580	6830	7888	8817	150	15370	18820	21700	24300
200	4829	5920	6826	7674	200	13310	16400	18800	21000
300	3944	4829	5577	6233	300	10870	13310	15370	17180
500	3055	3740	4320	4829	500	8418	10310	11940	13310
750	2420	3055	3522	3944	750	6872	8418	9720	10870
1000	2160	2646	3052	3413	1000	5950	7290	8420	9410
1250	1932	2366	2732	3052	1250	4340	5320	7540	8415
1500	1761	2160	2490	2789	1500	4860	5970	6860	7672
1750	1634	2000	2310	2582	1750	4500	5500	6366	7115
2000	1530	1870	2150	2415	2000	4209	5155	5970	6655

DISCHARGES OF GAS.—*Continued.*

LENGTH IN YARDS.	8 INCHES DIAMETER.			
	1	1.5	2	2.5
100	38650	47350	54640	61100
150	31550	38640	44600	49940
200	27340	33460	38600	43200
300	22310	27340	31550	35270
500	17280	21170	24400	27340
750	14100	17280	19800	22310
1000	12220	14960	17280	19320
1250	10940	13650	15520	17280
1500	9900	12200	14040	15800
1750	9237	11300	13040	14600
2000	8640	10585	12200	13670

LENGTH IN YARDS.	10 INCHES DIAMETER.			
	1	1.5	2	2.5
500	30100	37100	42600	47700
750	24650	30190	34800	39000
1000	21640	26150	30100	33750
1500	17400	21300	24760	27560
2000	15050	18500	21300	23850
2500	13175	16136	18632	20880
3000	12027	14561	17008	19016
4000	10413	12756	14729	16468

LENGTH IN YARDS.	12 INCHES DIAMETER.			
	1	1.5	2	2.5
500	47600	58320	67200	75240
750	38800	47600	55000	61470
1000	33660	41200	47600	53240
1500	27500	33600	38880	43515
2000	23800	29250	33600	37620
2500	21190	26100	30116	33631
3000	19440	23800	27500	30740
4000	16830	20600	23800	26620

LENGTH IN YARDS.	14 INCHES DIAMETER.			
	1	1.5	2	2.5
500	98000	120200	138240	154560
750	79770	97740	113200	128020
1000	69120	84670	98000	109260
1500	56600	69120	79800	89230
2000	49000	60100	69120	77280
2500	43680	53540	61824	69120
3000	39885	48870	56600	64000
4000	34560	42340	49000	54630

DISCHARGES OF GAS.—*Continued.*

LENGTH IN YARDS.	20 INCHES DIAMETER.				LENGTH IN YARDS.	24 INCHES DIAMETER.			
	1	1.5	2	2.5		1	1.5	2	2.5
500	170600	204600	241000	270000	500	271200	326000	375000	425800
750	139600	170600	197600	222400	750	217200	271200	310000	344000
1000	120744	147900	170600	191000	1000	189200	233280	271200	301160
1500	98800	120700	139600	155800	1500	155000	190500	217200	245800
2000	85300	102300	124500	135000	2000	135600	163000	187600	212900
2500	76500	93500	108000	120744	2500	119000	145500	168000	194400
3000	69800	85300	98800	110200	3000	108600	135600	155000	172000
4000	60370	73950	85300	95500	4000	95350	116640	135600	150580

LENGTH IN YARDS.	30 INCHES DIAMETER.				LENGTH IN YARDS.	36 INCHES DIAMETER.			
	1	1.5	2	2.5		1	1.5	2	2.5
500	468000	574000	664000	744200	500	744000	912000	1212000	1256400
750	384000	468000	558900	607600	750	606000	744000	856000	1032000
1000	332000	406000	468000	526000	1000	530000	644000	744000	832000
1500	272070	332760	384140	457600	1500	428500	524860	606000	677630
2000	234000	287000	332000	372100	2000	372000	456000	524880	628200
2500	210000	257000	29800	332000	2500	332000	408000	468000	530000
3000	292000	234000	270000	303800	3000	303000	372000	428000	516000
4000	166000	203000	234000	263000	4000	265000	322000	372000	416000

TABLE, EXHIBITING THE PROPORTIONATE SIZE AND LENGTH OF SMALL PIPE FOR AN UNINTERRUPTED FLOW OF GAS AND A READY LIGHT.

SIZE OF TUBING.	GREATEST LENGTH ALLOWED.	GREATEST NO. BURNERS.
¼ inch.	6 feet.	1 burner.
⅜ "	20 "	3 "
½ "	30 "	6 "
⅝ "	40 "	12 "
¾ "	50 "	20 "
1 "	70 "	35 "
1¼ "	100 "	60 "
1½ "	150 "	100 "
2 "	200 "	200 "

MOTION OF GAS IN PIPES.

The following is the formula on which the foregoing tables were computed, in which—

Q = Quantity of gas in cubic feet per hour.
L = Length of pipe in yards lineal.
D = Diameter of pipe in inches.
H = Head of water pressure in inches.
G = Specific gravity of gas = .400.

$$Q = 1350\ D^2 \sqrt{\frac{H\ D}{G\ L}}$$

$$D = .056^5 \sqrt{\frac{Q^2\ G\ L}{H}}$$

If it is desired to ascertain the quantities discharged of gas of any other specific gravity, multiply the quantities indicated in the above tables by the square root of .4, and divide the product by the square root of the specific gravity of the other gas. See table on next page.

If the length of the pipe is one-fourth of the lengths given in the table, the discharge of gas will be doubled.

If the length of the pipe is four times greater than the lengths in the table, the discharge of gas will be only one-half.

Four times the pressure doubles the discharge of gas.

TABLE, SHOWING SPECIFIC GRAVITY OF GAS OF DIFFERENT ILLUMINATING POWERS IN STANDARD SPERM CANDLES.—AIR BEING 1.000.

No. CANDLES.		SPEC. GRAV.	No. CANDLES.		SPEC. GRAV.
10	Very Approximately.	.380	21	Very Approximately.	.522
11	" "	.392	22	" "	.537
12	" "	.405	23	" "	.550
13	" "	.416	24	" "	.565
14	" "	.430	25	" "	.585
15	" "	.443	26	" "	.605
16	" "	.455	27	" "	.625
17	" "	.468	28	" "	.645
18	" "	.482	29	" "	.662
19	" "	.495	30	" "	.678
20	" "	.508	31	" "	.694

Inside lights consume 4 cubic feet per hour.
External lights consume 5 cubic feet per hour.

In winter, each lamp consumes, per month, 1800 to 2500 cubic feet.
In summer, each lamp consumes, per month, 1000 to 1800 cubic feet.
Average consumption for each lamp = 21000 cubic feet per year.
Private burners average about = 5000 cubic feet per year.

FINAL TESTS.

Upon the completion of a water system, and in making the final tests of lines of pipe, care should be exercised to withdraw all air from the main.

By means of practical tests it has been shown that air collects at the low as well as at the high points of the line. When hydrants are not in close proximity to these points it is highly necessary to tap the main with a wrought-iron pipe through which the air and water may escape. Before putting on the pressure, water should be allowed to flow through the pipe until every indication of the presence of air shall have passed away. This frequently takes two or three days.

The presence of air in water can only be detected by filling a glass with the water. If air is present it will be seen rising to the top of the glass in a white cloud. *A test should not be made until glasses of water caught at the hydrants no longer show the presence of air.*

As water is a non-compressible fluid, hydrants should be left open throughout the entire test of direct pumping works, as otherwise there would be no allowance made for the water to escape, which the pumps force into the mains.

COST OF EXCAVATION.

Excavation for pipe laying differs so widely in the various kinds of soil found in the cities and towns of this country that it will be impossible to give any but an approximate estimate of the cost of trenching and back-filling.

But we will give an estimate of the cost of trenching, based on clay or loam soil, entirely free from rock, shale, or hard-pan, and sufficiently stiff to stand and not cave, with labor at $1.50 per day.

When rock, shale, hard-pan, macadam or gravel streets are to be excavated an additional percentage will have to be added to the estimate here given, in proportion to the extra labor required.

The estimate for back-filling may seem somewhat excessive, but we contemplate ramming and putting the streets in as good condition as they were prior to their being excavated.

PIPE LAYING.

COST OF EXCAVATING AND BACK-FILLING.

Size of Pipe.	Width of Trench.	Depth of Trench.	Cost Excavating per Lineal Foot.	Cost of Back Filling per Foot.	TOTAL.
4 inches.	2 feet.	4 feet, 6 inches.	6 cents.	3 cents.	9 cents.
6 "	2 "	4 " 8 "	6½ "	3½ "	10 "
8 "	2 " 4 in.	4 " 10 "	7½ "	4 "	11½ "
10 "	2 " 6 "	5 "	8½ "	4½ "	13 "
12 "	2 " 8 "	5 " 2 "	10 "	5 "	15 "
16 "	3 "	5 " 8 "	15 "	8 "	23 "
20 "	3 " 6 "	6 "	20 "	10 "	30 "
24 "	3 " 8 "	6 " 4 "	25 "	12 "	37 "

COST OF PLACING AND JOINTING PIPE.

4 inch per lineal foot	2 cents.	12 inch per lineal foot	7 cents.
6 " " " "	2½ "	16 " " " "	9 "
8 " " " "	4 "	20 " " " "	11 "
10 " " " "	5 "	24 " " " "	12 "

These prices include the extra labor in setting the specials that may be needed.

EXCAVATION IN CUBIC YARDS PER 100 FEET.

Depth of Trench in Feet.	WIDTH OF TRENCH IN FEET.						
	2	2½	3	3½	4	4½	5
3	22.222	27.777	33.333	38.888	44.444	50.000	55.555
3½	25.926	32.037	38.888	45.370	51.851	58.333	64.814
4	29.630	37.037	44.444	51.851	59.259	66.666	74.074
4½	33.333	41.666	50.000	58.333	66.666	75.000	83.333
5	37.037	46.296	55.555	64.814	74.074	83.333	92.592

TABLE SHOWING WEIGHT OF LEAD AND YARN USED IN LAYING OUR CAST IRON PIPE.

WATER.

Diameter of Pipe.	Depth of Lead.			
	2 inches.		1½ inches.	
	Pounds Lead used.	Pounds Yarn used.	Pounds Lead used.	Pounds Yarn used.
Inches.				
2*	1.53	.140		
3	4.85	.089	3.75	.148
4	6.32	.251	5.01	.329
5	7.50	.277	5.95	.366
6	8.68	.321	6.88	.424
8	11.03	.471	8.75	.605
10	13.53	.578	10.73	.742
12	15.88	.582	12.60	.775
14	18.67	.684	14.81	.912
16	21.03	.642	16.68	.899
18	23.68	.867	18.78	1.157
20	26.33	.966	20.88	1.288
24	31.04	1.137	24.61	1.516
30	38.17	1.631	30.37	2.175

GAS.

Diameter of Pipe.	Depth of Lead.			
	2 inches.		1½ inches.	
	Pounds Lead used.	Pounds Yarn used.	Pounds Lead used.	Pounds Yarn used.
Inches.				
2*	1.48	.135		
3	4.75	.086	3.53	.144
4	6.02	.238	4.81	.313
5	7.14	.267	5.71	.352
6	8.53	.316	6.77	.417
8	10.88	.465	8.65	.597
10	13.24	.566	10.50	.726
12	15.76	.578	12.50	.770
14	18.24	.668	14.46	.891
16	20.74	.633	16.44	.886
18	23.39	.856	18.55	1.142
20	25.74	.941	20.41	1.254
24	30.45	1.115	24.14	1.486

*In pipes two inches in diameter the depth of lead is one inch. No allowance is made in the above table for waste and loss in melting.

[From a paper by Wm. Kent, M. E., in transactions of American Society of M. E., Volume V. 1.]

TABLE OF DIMENSIONS OF CHIMNEYS FOR STEAM BOILERS.

Diameter of Round Chimney in Inches.	Height of Chimney in Feet.											Side of Square Chimney in Inches.
	50	60	70	80	90	100	110	125	150	175	200	
18	23	25	27	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	16
21	35	38	41	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	19
24	49	54	58	62	. . .	. .	. . .	. . .	. . .	. . .	. .	22
27	65	72	78	83	. . .	. . .	. . .	. . .	. . .	. . .	. . .	24
30	84	92	100	107	113	. . .	. . .	. . .	. . .	. . .	. . .	27
33	. . .	115	125	133	140	. . .	. . .	. . .	. . .	. . .	. . .	30
36	. . .	141	152	163	173	182	. . .	. . .	. . .	. . .	. . .	32
39	. . .	. . .	183	196	208	219	. . .	. . .	. . .	. . .	. . .	35
42	. . .	. . .	216	231	245	258	271	. .	. . .	. . .	. . .	38
48	. . .	. . .	.	311	330	348	365	389	. . .	. . .	. . .	43
54	. . .	. .	. . .	. . .	427	449	472	503	551	.	. . .	48
60	. .	. . .	. .	. . .	536	565	593	632	692	748	.	54
66	. . .	. . .	. . .	. . .	. . .	694	728	776	849	918	981	59
72	. . .	. . .	. .	. . .	.	835	876	934	1023	1105	1181	64
78	. . .	. . .	. . .	. . .	. . .	. . .	1038	1107	1212	1310	1400	70
84	.	. .	. .	. . .	.	. . .	1214	1294	1418	1531	1631	75
90	. . .	. . .	. . .		. . .	. . .	. .	1496	1639	1770	1893	80
96	. . .	. . .	. . .	. . .	. .	.	. .	. . .	1876	2027	2167	86

The above table is based on the generally adopted standard of one horse-power, viz.: The hourly evaporation of thirty pounds of water into dry steam from feed water at 100 degrees Fahr., and under a pressure of seventy pounds per square inch above the atmosphere.

WEIGHTS AND MEASURES.

THE METRIC SYSTEM of weights and measures was adopted and legalized by act of Congress in 1866. Although it has since then been used by some of the different departments of the government, notably by the Coast Survey and the Engineer corps of the army, it has by no means superseded the old style of weights and measures in vogue in commercial usage.

The *meter* equaling 39.368505 inches, or 3.280709 feet lineal, is the unit of *length*, *area*, and *volume* in this system, and a cubic meter of water at its maximum density, 39.2°, weighs 2204.7 pounds avoirdupois.

The gram is the unit of weight, and is equal to the weight of a cubic centimeter of distilled water at its maximum of density in vacuo = .002204.7 pounds avoirdupois, at sea level, latitude of Paris, barometer 29.922 inches.

The Liter is the unit of measures of capacity. A Liter = 1.057 liquid quarts or .908 dry quarts.

A curious coincidence in the adoption of units of measurement of the meter and the standard yard is that neither are what they were originally intended to be. The meter was intended to be the one-ten-millionth part of the distance from either pole of the earth to the equator; but after it had been introduced into use, errors were discovered in the calculations employed for ascertaining that distance.

The British standard yard, the standard also for all ordinary purposes in this country, is theoretically that of a pendulum vibrating seconds at the level of the sea in the latitude of London, in vacuum, with thermometer at 62° Fahr. The length of this pendulum is supposed to be divided into 39.1393 equal parts, called inches, and 36 of these inches were adopted as the standard yard for both countries; but the preliminary standard being destroyed by fire in 1834, it was found to be impossible to restore it by measurement of the pendulum, so as to be exactly correct with the one formerly used. The consequence is that the present British yard is shorter than that of the United States by about 1 part in 17230, which is equal to 3.677 inches in a mile, or to $\frac{1}{4}$th of an inch in 100 feet.

We append the metric system of weights and measures.

COMPLETE TABLE OF THE METRIC SYSTEM.

Relative Values.	Length.	Weight.	Capacity.	Surface.	Solidity.
10,000	Myriameter. (Mm)				
1,000	Kilometer. (Km)	Kilogram. (Kg)	Kiloliter. (Kl)		
100	Hektometer. (Hm)	Hektogram. (Hg)	Hektoliter. (Hl)	Hektar. (Ha)	
10	Dekameter. (Dm)	Dekagram. (Dg)	Dekaliter. (Dl)		Dekaster. (Ds)
Unit.	Meter. (m)	Gram. (g)	Liter. (l)	Ar. (a)	Stere. (s)
.1	Decimeter. (dm)	Decigram. (dg)	Deciliter. (dl)	Deciar. (da)	Decister. (ds)
.01	Centimeter. (cm)	Centigram. (cg)	Centiliter. (cl)	Centiar. (ca)	
.001	Millimeter. (mm)	Milligram. (mg)	Milliliter. (ml)		

TROY WEIGHT.

UNITED STATES AND BRITISH STANDARD.

24 grains	= 1 pennyweight, dwt.
20 pennyweights	= 1 ounce, oz. = 480 grains.
12 ounces	= 1 pound, lb. = 240 dwt. = 5760 grains.

Troy weight is used for gold and silver and precious stones. A carat in the United States = 3.2 grains; in London = 3.17 grains; in Paris = 3.18 grains, divided into 4 jewelers' grains.

Perfectly pure gold is called fine or 24 carat gold; when alloyed, it is supposed to be divided into 24 equal parts; if 14, 15, 18, or 20, etc., of these are pure gold, the alloy is said to be 14, 15, 18, or 20, etc., carat fine.

United States trade dollar weighs 420 grains; United States legal tender dollar weighs 412.5 grains; United States "subsidiary" half dollars, 192.9 grains; United States 20 dollar gold piece, 516 grains.

AVOIRDUPOIS WEIGHT.

UNITED STATES AND BRITISH STANDARD.

27.34375 grains	= 1 dram.
16 drams	= 1 ounce = 437.5 grains.
16 ounces	= 1 pound = 256 drams = 7000 grains.
28 pounds	= 1 quarter = 448 ounces.
4 quarters	= 1 hundred weight, cwt. = 112 lbs.
20 cwt.	= 1 ton = 80 quarters = 2240 lbs.
1 stone	= 14 pounds.
1 quintal	= 100 pounds.

APOTHECARIES WEIGHT.

UNITED STATES AND BRITISH STANDARD.

20 grains = 1 scruple.
3 scruples = 1 dram = 60 grains.
8 drams = 1 ounce = 24 scruples = 480 grains.
12 ounces = 1 pound = 96 drams = 288 scruples = 5760 grs.

In Troy and Apothecaries weights, the *grain*, *ounce*, and *pound* are the same.

LONG MEASURE.

The United States and British standards are usually supposed to be the same, but in fact the British measures are short, for reasons explained on page 85. The measurements below are United States standard.

12 inches = 1 foot = .3048121 meter.
3 feet = yard = 36 inches.
5½ yards = 1 pole, perch, or rod = 16½ feet = 198 inches.
40 rods = 1 furlong = 220 yards = 660 feet.
8 furlongs = 1 mile = 320 rods = 1760 yds. = 5280 ft. = 63360 in.
3 miles = 1 league = 24 furlongs = 960 rods = 5280 yards = 15840 feet.
A point = $\frac{1}{72}$ of an inch.
A palm = 3 inches.
A line = 6 points = $\frac{1}{12}$ inch.
A hand = 4 inches.
A span = 9 inches.
A fathom = 6 feet.
Gunter's chain = 66 feet or 4 rods.
80 Gunter's chains = 1 mile.
A cable's length = 120 fathoms = 720 feet.
A link = 7.92 inches = 100 in chain.

A *knot*, or nautical mile, is the length of one minute of longitude of the earth at the equator, level of the sea, or the $\frac{1}{21600}$ part of the earth's equatorial circumference.

By the United States standard this is = 1.52664 common statute or land mile = 1855.11 meters = 2028.69 yards = 6086.07 feet.

By British standard, the *knot* is 4 inches longer than the United States.

SQUARE OR LAND MEASURE.

UNITED STATES AND BRITISH.

144 square inches = 1 square foot.
9 square feet = 1 square yard = 1296 square inches
30¼ square yards = 1 square rod = 272¼ square feet.
40 square rods = 1 rood = 1210 square rods = 10890 square feet.
4 roods = 1 acre = 160 rods = 4840 sq. yds. = 43560 sq. ft.

A *section* of land is 1 mile square, and contains 27878400 square feet = 3097600 square yards = 640 acres.

CUBIC OR SOLID MEASURE.

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.

A CUBIC FOOT is equal to—

1728 cubic inches; or .037037 cubic yards; or .803564 U. S. struck bushels of 2150.42 cubic inches; or 3.21426 U. S. pecks; or 7.48052 U. S. liquid gallons of 231 cubic inches; or 6.42851 U. S. dry gallons; or 6.23210 British or imperial gallons of 277.274 cubic inches; or .23748 U. S. liquid barrel of 31½ gallons; or .002832 myriolitre; or kilolitre; or .283202 hectolitre; or 2.83202 decolitres or centisteres; or 28.3202 litres.

A CUBIC INCH is equal to—

.0005787 cubic feet; or .004329 gallons; or 16.38901 millilitres; or 1.638901 centilitres; or .1638901 decilitres; or .01638901 litres.

A CUBIC YARD is equal to—

27 cubic feet; or 46656 cubic inches; or .0764646 myriolitre; or .764646 kilolitre or cubic *metre*; or 7.64646 hectolitres; or 76.4646 decolitres; or 764.646 litres or cubic decimetres; or 7646.46 decilitres; or 21.69623 U. S. struck bushels; or 17.35707 U. S. heaped bushels; or 21.033326 British bushels.

A U. S. struck bushel equals 1 24445 cubic feet = 2150.42 cubic inches.

A U. S. heaped bushel equals 1.55556 cubic feet = 2688.008 cubic inches.

DRY MEASURE.

UNITED STATES STANDARD.

2 pints = 1 quart = 67.2006 cubic inches = 1.16365 liquid quarts.
4 quarts = 1 gallon = 8 pints = 268.8025 cub. in. = 1.16365 liq. gal.
2 gallons = 1 peck = 16 pints = 8 quarts = 537.6050 cubic inches.
4 pecks = 1 bushel = 64 pints = 32 quarts = 8 gallons = 2150.42. cubic inches.

The basis of the above table is the old British Winchester struck bushel. Its dimensions by law are 18½ inches inner diameter, 19½ inches outer diameter, and 8 inches deep; when heaped, the cone not to be less than 6 inches high.

DRY MEASURE.

U. S. pint	weighs	1.2104	pounds	avoir.	of water.
" quart	"	2.4208	"	"	"
" gallon	"	9.6834	"	"	"
" peck	"	19.3668	"	"	"
" bushel, struck	"	77.4670	"	"	"

LIQUID MEASURE.

UNITED STATES STANDARD ONLY.

4 gills	= 1 pint = 28.875 cubic inches.
2 pints	= 1 quart = 57.750 cubic inches = 8 gills.
4 quarts	= 1 gallon = 231. cubic inches = 8 pints = 32 gills.
63 gallons	= 1 hogshead.
2 hhds.	= 1 pipe or butt.
2 pipes	= 1 ton.

The basis of this measure in the United States is the old British wine gallon of 231 cubic inches.

To reduce IMPERIAL LIQUID measures to United States ones of the same name × by 1.20032.

To reduce IMPERIAL DRY measures to United States ones of the same name × by 1.031515.

LIQUID MEASURE.

U. S. gill weighs .26005 pounds avoirdupois of water.

" pint " 1.0402 " " "
" quart " 2.0804 " " "
" gallon " 8.3216 " " "

IMPERIAL MEASURE—LIQUID AND DRY.

GREAT BRITAIN ONLY.

4 gills = 1 pint = 34.6592 cubic inches.
2 pints = 1 quart = 69.3185 cubic inches.
2 quarts = 1 pottle = 138.637 cubic inches.
2 pottles = 1 gallon = 277.274 cubic inches.
2 gallons = 1 peck = 554.548 cubic inches.
4 pecks = 1 bushel = 2218.192 cubic inches.
4 bushels = 1 coomb = 8872.768 cubic inches.
2 coombs = 1 quarter = 17745.536 cubic inches.

This system is established through Great Britain to the exclusion of old ones. Its basis is the imperial gallon of 277.274 cubic inches, or 10 pounds avoirdupois of pure water; temperature, 62° Fahr.; barometer, 30″.

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